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H.M.S. DREADNOUGHT.

THE MOST POWERFUL WAR VESSEL IN THE WORLD.

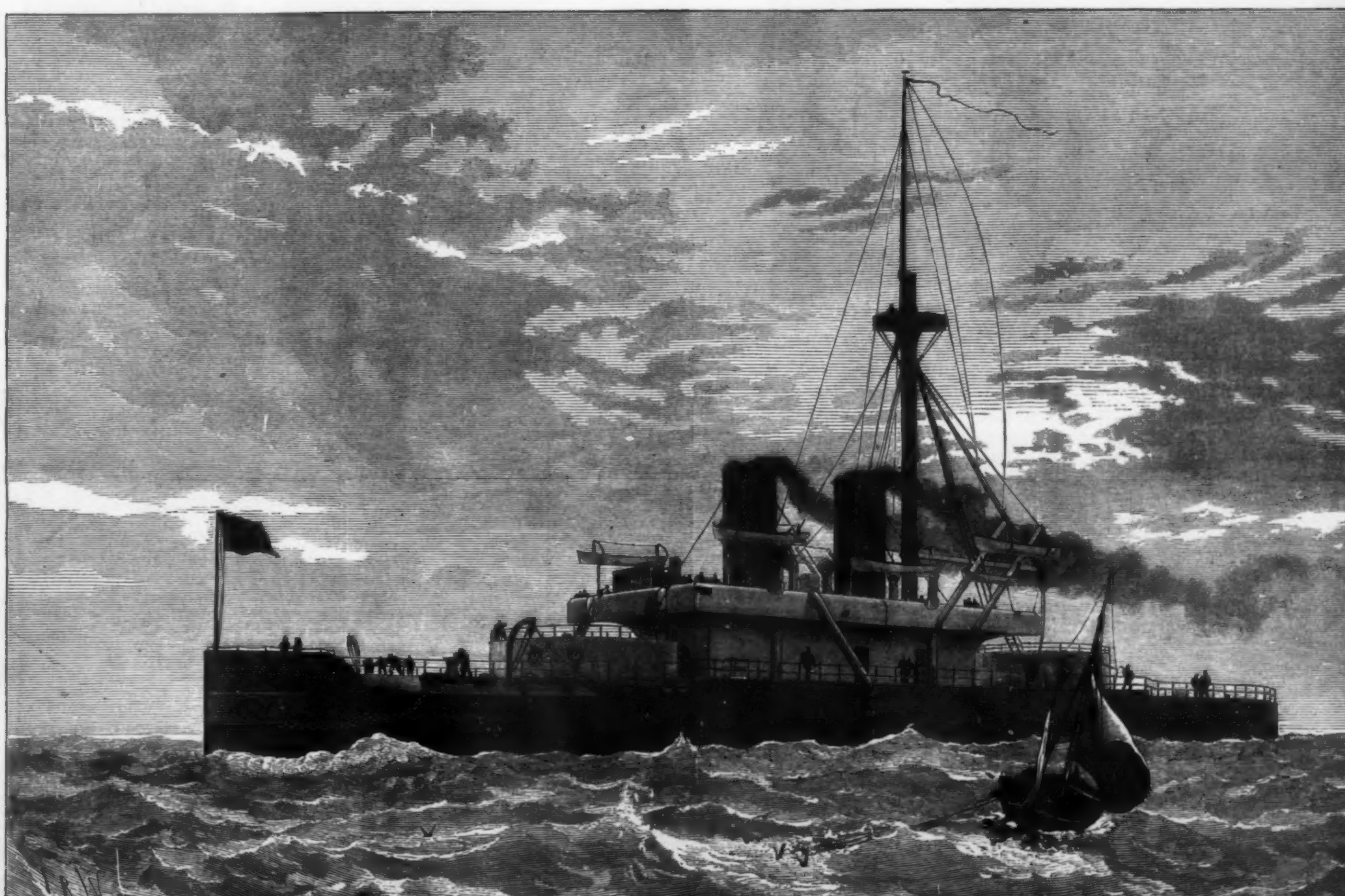
THE Dreadnought, double screw iron turret-ship, armor plated, 10,886 tons, 8,000-horse power, was built at Pembroke Dockyard, but has been completed at Portsmouth. With her four 38-ton guns, worked by hydraulic power, this ship will be the most powerful fighting vessel in the world. She is one of the three mastless vessels which were proposed by Mr. Childers; but, though belonging to the same type as the Devastation and the Thunderer, she differs from them in some important particulars, the results of growing experience, and exhibits the steady development which is being made in modern ships of war. These ships of the Devastation class, in which a vast advance was made, represent the first-class fighting ships, carrying heavier armor and armaments than any vessels previously built, and capable of fighting an action in mid-ocean. For this purpose they have their stability increased by a half-raised unarmored forecastle, and by an unarmored superstructure on each side of the breastwork, protecting the foundations of the turrets, whereby the freeboard amidship is raised to the full height of the breastwork deck. The armament of the Devastation consists of four 35-ton guns. In the sister ship, the Thunderer, the armament was still* further increased, and the formidable offensive fire was considerably augmented by the first introduction of hydraulic gun gear. The Dreadnought is a further improvement upon the other ships in various ways, several modifications of the earlier turrets having been introduced in her construction at the suggestion of Admirals Elliot and Ryder. The most important is the erection of a central box, in place of the narrow breastwork of the Devastation. The unarmored superstructures in the latter ship were added to the original design in obedience to remonstrances from outside, notwithstanding the opinion of the Committee on Designs that the addition was not necessary for safety. In the Dreadnought, to secure a large reserve of buoyancy and stability, the breastwork has been carried out flush with the side of the ship, by which an armored wall eleven inches thick is obtained amidship. It was proposed to take advantage of this widening of the breastwork to place the turrets out of line with each other, as in the case of the Inflexible, so that the whole armament might be fired direct ahead and astern as well as abeam. This idea, however, was not adopted, both the turrets being placed in line, as in the Devastation; but the increased space has enabled the whole crew, some 380 all told, to be accommodated in the breastwork, which is lighted and ventilated from above. As proposed by the constructor, the lateral extension of the breastwork would have still necessitated the retention of the cul-de-sac, which has been condemned by many naval architects, and by none more emphatically than by Mr. Reed. But the constructor was of a different opinion, and even went so far as to believe that the light forecastle of the Devastation might be dispensed with. The forecastle was partly designed to give lifting power to the bow; and the constructor stated he did not consider that lifting power was required there in the Devastation. He, on the whole, would rather not have it, preferring to avoid pitching as much as possible, which weight at the end encouraged. With a high bow a ship rises with more of a spring, and makes a corresponding plunge afterward, whereas a low deck forward, immersed, would, it was believed, check her rising by a kind of bilge keel action. Pitching, of course, exposes the bottom to shot. This is a necessary evil in masted ships, in which the decks have to be kept dry, but it has been considered this danger could be avoided in the case of monitors. The construction of the Dreadnought was delayed until this and several other matters had been further discussed The alternative plan was either to dispense with forecastles altogether and allow the ship to bury herself forward, or to build up the ends flush with the top of the breastwork. This latter plan was ultimately adopted in the case of the Dreadnought, a slight inclination in the weather deck being allowed fore and aft to admit of the guns being depressed. The cul-de-sac has consequently been obliterated, and a high freeboard has been obtained of nearly the same height throughout the length of the ship. In the Dreadnought, again, the armor belt, which was cut down in the two sister ships, is completed forward, and the recommendations of Admirals Elliot and Ryder for the protection of the fore magazine of the Devastation have also been carried out by sloping the bow armor down to the spur. The armor-strakes along the length of the breastwork are of a parallel thickness before and aft, while they taper to 8 inches in thickness at the stem and stern. The armor on the ends of the breastwork is 13 inches, and that on the side 11 inches, except for a length of about 20 feet in the wake of each turret, where the plating is 14 inches thick. In the Dreadnought the constructor has also introduced another valuable improvement in the shape of a longitudinal watertight bulkhead between the respective sets of engines and boilers. In the event of injury to the ship from rams, torpedo attacks, or other such engines of war, it would act as a valuable protective agent, provided always that the weight of the inrush of water could be equally distributed.

The total weight of the Dreadnought's hull is 7,350 tons, and the weight of armor, engines, coals, etc., amounts to 3,598 tons. The estimated cost of the hull is £400,000. She will carry 1200 tons of coal, will be provisioned for a month, and will be armed with a 65-pounder Gatling gun, in addition to her turret armament.—*Illustrated London News.*

TRIAL OF COMPETITIVE SHOT AGAINST ARMOR.

A VERY important trial of armor-piercing shot submitted by the most successful makers has recently been commenced at Shoeburyness in connection with the work of Gen. Younghusband's Committee on Heavy Guns. The investigation of this particular question is conducted by Col. Inglis, R.E., and certain members associated with him for this work. At present the investigation, which promises to be as far as possible an exhaustive one, is in its first stage. Consequently it would not be fair in any sense to give results as if they were final. Besides this, however, the committee are at present trying the various materials under such conditions as admit of a strict comparison; and to do this, similarity of shape, etc., must be secured, and thus a form may be insisted on which may not be equally well suited to each particular material. At this stage of the trial, then, while it may be instructive to notice the behavior of the shot in certain cases, we must remember that the manufacturers' ideas are not being carried out, for their metal is being tested under certain given conditions, which may be disadvantageous.

At the commencement of an important series of experiments it is a great matter that the confidence of the competitors should be won by a statement of conditions which commend themselves as securing complete fairness in the trial. This appears to be the case in the present instance, and is the more to be noticed inasmuch as, rightly or wrongly, it cannot be said to be the feeling with regard to some of the experiments conducted by foreign Powers. Probably our readers will see that the arrangements deserve the high character they have earned when we describe them. The first trial is one of the metal itself, submitted by each manufacturer. Each is called upon to send in a 9-in. projectile made of the service weight and shape—that is to say, 268 lbs. weight, including gas-check, with an ogival head struck with a radius of 1½ diameter. In most cases the inventors cast their own projectiles, but in certain instances they were



H.M.S. DREADNOUGHT, THE MOST POWERFUL WAR SHIP IN THE WORLD.

cast at Woolwich Arsenal of the metal sent thither for that purpose. The whole of them have been studded in the Arsenal with the gun-metal studs of the service pattern, and weighted up to the same weight, namely, 268 lbs., the dimensions being at the same time tested. Manufacturers were invited to send in steel or chilled metal projectiles, whichever they might prefer. Plates 12 ins. thick have been supplied by Messrs. Brown to test the powers of the shot. These plates were made 4 ft. wide and 16 ft. long, and then cut in four lengths, so that four plates, each 4 ft. by 4 ft., would be supplied from the same furnace heat. The whole of the plates were specified to be of the highest quality. Each 4-ft. plate thus obtained is fitted with arms, so as to enable it to be suspended and subjected in this condition to the blow of one projectile striking near the center of its face. The service 9-in. gun is employed, with an increased charge of 65 lbs. of pebble "P2" powder, which gives a striking velocity averaging about 1,500 ft. at the target, which is at 50 yards from the gun. The penetration theoretically due to this with the shot in question works out about 12·5 ins.; that is to say, the point of the shot ought theoretically to get through a plate about 12·5 ins. thick. Practically, it would be a very excellent shot that would do so. The projectiles which have been supplied, in answer to the invitations sent out, are as follows: *Chilled metal shot*—(1) Gruson's; (2) Krupp's; (3) Finspong; (4) Gregorini; (5) the Royal Laboratory service kind; (6) an experimental kind designated "Palliser's improved." *Steel shot*—(7) Terre Noire; (8) Whitworth; (9) Hadfield; (10) Landore; (11) Vickers'; (12) a steel shot of Vickers' with a chilled iron point; and lastly (13) Cammell's compound shot, made on Wilson's idea of steel with a chilled iron point.

With regard to the general properties of these various shot, we should expect the chilled iron to break up much more than the steel, but to exhibit greater hardness. Previous experience would lead us to expect the (Swedish) Finspong shot to be of very excellent iron, but rather soft. After what we have heard of steel projectiles on the Continent, we were rather surprised to find that four shots out of the five submitted for trial were of chilled metal. There is more difference between one maker's steel and another's than exists theoretically in chilled iron. Some shot are forged and turned, some cast solid and bored out. Hadfield's are cast of crucible steel, the projectile being cast hollow, and tool-work on the exterior being avoided by casting the projectile to its final dimensions as nearly as possible, so as to retain the skin uninjured. Whitworth's is cast under pressure, and the point made from a separate piece of metal and screwed into the body. Some steel, notably the Landore, is made by the Siemens-Martin process, as well as the "Terre Noire"—French steel—which had been very loudly praised, but is little known in this country. The following results, speaking generally, were obtained:

(1) *Gruson's* (chilled).—The first projectile fired (No. 2095) broke up on beginning to enter the plate, the point only reaching to the depth of 8½ ins., and the surrounding portions to the depth of 4¾ ins. or less. This shot is clearly not a fair specimen, having broken up too soon to give such an effect as might be considered to represent its power (*vide* Figs. 1, 2, and 3). The second round (No. 2101) was a much better one, the head getting completely through the target, and breaking away from the body through the front stud holes. This effect is probably rather deceptive, for the plate was not a well-welded one. The joints of the bent portions were separated so far that the fingers might be inserted between the layers near the edge, and a blade of straw might be pushed in to the distance of perhaps a foot. Imperfect welding facilitates penetration with an ogival-headed projectile by enabling the targets to accommodate themselves to the bending-back caused by the shot's head as it opens its way through the plate. In other words, it approaches the condition of laminated armor, which yields to this kind of penetration more easily than solid plate, 6 ins. of laminated being found to be equivalent to a single 4-in. plate.

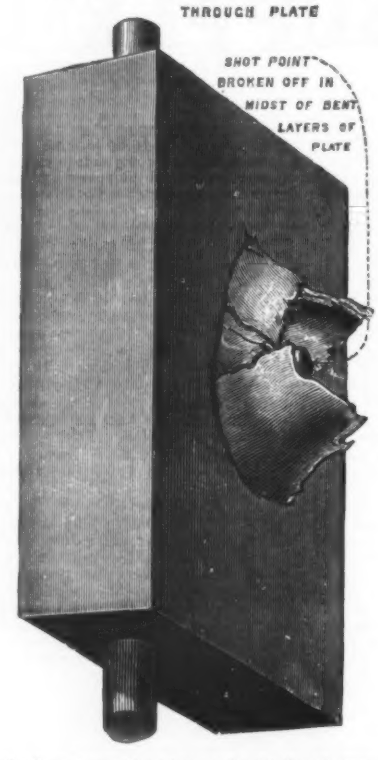
FIG. 8

CAMMELL'S (WILSONS) PROJECTILE

(Nº 2087) STEEL WITH CHILLED POINT

SHOWN WITH POINT APPEARING

THROUGH PLATE



(2) *Krupp's* (chilled).—The first round (No. 2096) penetrated about 10½ ins., causing a slight bulge and cracking at the back of the plate, the shot breaking up. Krupp's second shot (No. 2102) very nearly penetrated the entire plate; the shot's head broke off just at front ring of studs, and came out, leaving daylight visible through the openings at the end of the shot-hole; the back of the plate was much bulged and opened.

(3) *Finspong* (chilled) (No. 2094) entered to a depth that cannot be measured at present, the shot remaining fixed in the plate, being bulged about the shoulders and anterior part of the body (*vide* Fig. 4). The metal is clearly of excellent quality, but soft. Finspong chilled shot (No. 2100) penetrated through the plate, the point projecting 1 in. through the back surface of the plate. The back of the plate was bulged, and opened in cracks extending about 25 ins. The head of the shot broke off from the body, but the latter remained, holding well together in one.

(4) *Gregorini* (chilled) (No. 2088) penetrated about 10 ins., the head separating from the body and opening out at the widest part of the opening about 10½ ins. At the back of the plate a slight bulge and crack were made. Gregorini (No. 2106) shot broke up, leaving head wedged in, as in the above-mentioned round. The plate was cracked at the back to a length of about 8½ ins., width 1 in.

(5) *The Royal Laboratory Service Pattern* (chilled) (No. 2082) penetrated the plate so far as got the point through, the back of the plate being bulged about 5 ins. and opened to a width of about 4 ins. The shot broke up. Royal Laboratory service pattern (No. 2107), penetration and effects somewhat similar to the above.

(6) *Palliser's Improved* (chilled) (No. 2087).—Penetration nearly through; shot broken in plate; back of plate bulged and cracked open in cracks 23 ins. long and over 1 in. wide in widest part. Palliser's improved (No. 2105).—Very similar effects; point just through; cracks at the back of plate 14 ins. long, 2 ins. wide at the widest part. The shot broke up, leaving daylight visible through a wide crack.

(7) *Terre Noire* (steel) (No. 2093).—Shot remained entire fixed in target, the base projecting to an extent of about 10 ins., the projectile being bulged and set up—*vide* Fig. 5—resembling the Finspong—Fig. 4—in appearance. The back of the target was bulged and cracked very slightly. Steel, Terre Noire (No. 2099), penetrated perhaps about 10 ins.; slight crack at back of target, with bulge of about 2½ ins.; shot remained entire, setting up to a diameter at the front part of the body of 10·32 ins.—*vide* Fig. 6.

(8) *Whitworth's* (compressed steel) (Nos. 2092 and 2098).—In these two the results were very similar, namely, a hole perforated through the plate of about the full diameter of the projectile, a large disk being detached at the back by the bending back of the metal tongues formed by the star-shaped tear made by ogival-headed shot. The diameter of

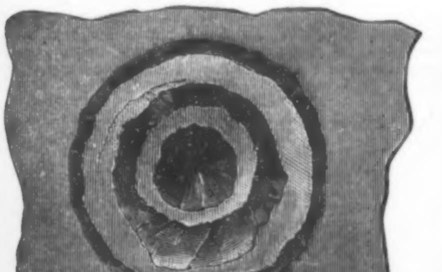


FIG. 1

IMPRESSION IN PLATE MADE BY GRUSON CHILLED PROJECTILE —— Nº 2095

FIG 2.

SECTION OF IMPRESSION

FIG. 3

GRUSON SHOT POINT

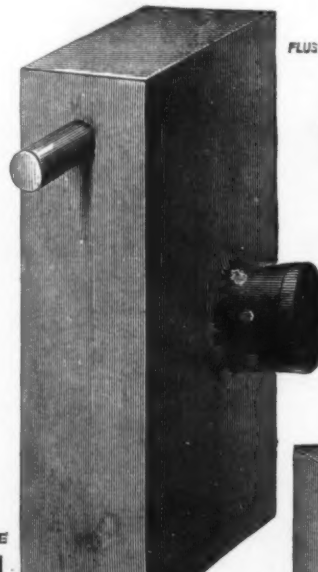


FIG. 5

TERRE NOIRE PROJECTILE (STEEL) Nº 2093

FRONT STUDS CLIPPED OFF FLUSH. REAR STUDS UNINJURED

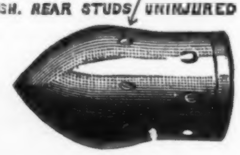


FIG. 6

TERRE NOIRE PROJECTILE (STEEL) Nº 2099 AFTER IMPACT

FIG. 9

PROFILE OF 12 IN. PLATE. AFTER IMPACT BY CAMMELLS PROJECTILE —— Nº 2103

VELOCITY 1520 FT PER SECOND

FIG. 10

VIEW OF CAMMELLS PROJECTILE —— Nº 2103 —— HEAD WITH POINT BROKEN THRO BACK OF PLATE

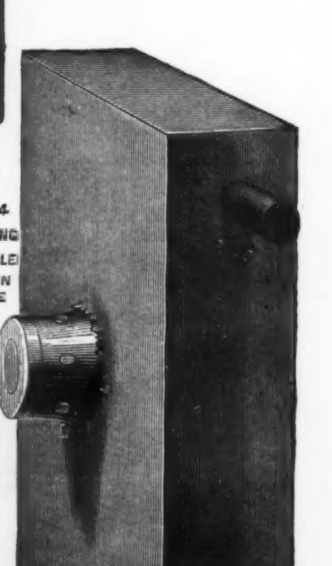


FIG. 4

FINSPONG PROJECTILE CHILLED METAL IN PLATE Nº 2094

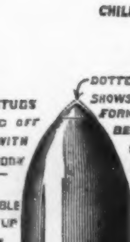


FIG. 7

WHITWORTH STEEL PROJECTILE. AFTER PASSAGE COMPLETELY THROUG 12 IN. PLATE

RECENT TRIALS OF SHOT AGAINST IRON ARMOR.

the disk so detached was about 23 ins. The projectile remained unbroken or cracked, its appearance being almost unaltered. The point of one, however, was slightly set up, as shown in Fig. 7, and the points and heads of both were rather more scored or scratched than chilled points. One shot was set up at the shoulder 0·13 in., the other only 0·05 in. One of these projectiles passed clean through the entire plate; the other did not quite do so, but must have barely failed to do it, the perforations in the plate being nearly identical in the two cases.

(9) *Hadfield's* (steel) (No. 2083).—Penetration nearly through—that is, about 11·9 ins., but no daylight visible. Back of plate bulged about 4 ins. and cracked. Shot base broke off; the front portion remained in one, but was set up and cracked. Steel, Hadfield's (No. 2086).—Penetration about 9 ins., but shot struck at a slightly inclined direction. Slight bulge, 2 ins. to 3 ins., and crack at back. Shot broke into three. Steel, Hadfield's (No. 2091).—Penetration about 10·75 ins. Shell bounded back unbroken, with gas-check attached. Body of shell cracked. Back of plate bulged nearly 3 ins., and cracked open to a width of over 2½ ins.

(10) *Landore* (steel) (No. 2085).—Penetration about 9½ ins. No daylight visible. Base of shell broke up rather small. Head and body set up. Diameter about shoulders about 10·25 ins. Steel, Landore (No. 2104).—Results not noted.

(11) *Vickers'* (steel) (No. 2084).—Not quite a direct blow. Penetration about 10½ ins. Base of shell broke up. Head entire to front ring of studs. Back of plate bulged about 3·8 ins. Crack, 1·5 in. wide.

(12) *Vickers'* (steel) (No. 2089).—Penetration about 8·5 ins., the indent being widened about 11·2 ins. at mouth. Shell bounded back whole, but much set up; cracked through at nearly every stud-hole. Back of target 1½ in. bulged, and cracked slightly.

(13) *Cammell's—Wilson's* (steel with chilled iron point)—(No. 2097).—Shot penetrated so as to leave the base only 2 ins. or 3 ins. short of the front of the plate. Front portion projecting through the back of the plate, and visible in the midst of the bent and open tongues of iron—*vide* Fig. 8. Part of the chilled point broken off. Portions of a large disk of metal about 23 ins. wide detached from plate at back. Steel and chilled point, Cammell's (No. 2103).—Shot penetrated so as to leave the front—from which the point had broken off—above 7½ ins. past the back of the plate. Very large portions of plate were torn and bent back—*vide* Figs. 9 and 10. There was a very great quantity of work done on this plate. The velocity of the shot, however, ought to be noted as a few feet higher than any hitherto fired, namely, 1,520 ft. per second.

A few remarks may be made with advantage on these results, qualifying them, as we have said, by the recollection that the experiments are in an early stage, and that the makers are conforming to a pattern which they did not choose and against which some protested.

The most striking feature is the behavior of the steel as compared with the chilled iron. The latter broke up on impact, with the exception of one Finspong shot, and in many cases the projectile was severed into very small fragments. On the other hand, when the steel broke, it was into a few fragments. The head merely separated from the body at the front ring of studs in some instances. The two Whitworth projectiles, one of Hadfield's, one of Vickers', and both the Terre Noire shot remained entire after impact, though in some cases cracked to a considerable extent. On the other hand, the chilled projectiles appeared to be the harder; the *points* in no instance were scored or set up, and the body was seldom set up either. The Finspong shot unquestionably behaved in an exceptional way, remaining entire, and also setting up like some of the steel projectiles. This would suggest that Messrs. Wilson and Vickers are on the right track in employing a chilled point on a steel body. The question, of course, is whether the two metals can be got to assimilate and combine without injury from a want of homogeneity. Wilson's shot unquestionably did well, but the chilled point broke in both instances. Might not a good result be got from steel shot cast in the ordinary chill mould?

The Whitworth shot far surpassed everything. Their completely symmetrical and almost unaltered form after quite penetrating the plates is an extraordinary illustration of what may be effected by steel. Probably no manufacturer can seriously hope to surpass the Whitworth metal in quality. Perhaps their ambition is to approach it as nearly as possible at a much less cost. The question of price cannot now be entered into; indeed, we have no data to guide us at present. The matter must, however, not be lost sight of, inasmuch as much may turn on it eventually. We do not pretend to say at what cost Sir J. Whitworth may turn out the projectiles that have produced such extraordinary results. If every shot that was issued to the navy were actually fired at an enemy, it would be hardly worth while considering the price, but as this is by no means the case—for only a certain percentage of them will be so fired—we cannot afford to disregard the question of cost. Steel seems likely to beat chilled iron. There are reasons for this that we cannot now discuss, but that we hope to make clear in a future article. The adoption of steel means increased cost. What degree of excellence may be obtained and at what price remains to be seen. With regard to the foreign shot, it is to be observed that the Gregorini metal has done better in Italy than on this occasion. It is therefore to be concluded that the method of casting in the Royal Arsenal does not suit this particular iron. Judgment as to the capabilities of this metal must be suspended. The same excuse, however, cannot be made for the Terre Noire steel projectiles, which have certainly fallen far short of the expectations that had been raised. One of Gruson's was very much better than the other which we have noticed as a faulty shot most probably. Krupp's are good for chilled metal, though not apparently better than our own service shot. The behavior of projectiles, however, would have to be very characteristic to enable us to speak strongly of the results of two or three rounds. It may be noticed that the word shot or steel has been used indiscriminately in this account, the same projectile now answering both functions. In these experiments it was fired as a shot, that is, without a bursting charge.—*Engineer.*

RAILWAY WORKING EXPENSES.—It appears from a mass of data collected upon the subject that the ratio of the working expenses of railways in various countries to their traffic receipts is as follows: Italy, 62½ per cent., France, 54½ per cent.; Belgium, private lines, 61¼ per cent.; State lines, 73 per cent.; Holland, 65¼ per cent.; Great Britain and Ireland, 54 per cent.; Switzerland, 48¼ per cent.; Russia, 58 per cent.; Germany, State lines, 66¼ per cent.; Spain, 42½ per cent.

TESTING THE VALUE OF GUNS BY FIRING UNDER WATER.

By HENRY A. MOTT, JR., Ph. D., E. M.

WHILE investigating the force of explosives under water with the object of perfecting a counter torpedo for Count Kolowrat, my attention was directed by Mr. Julius H. Striedinger, the well-known civil engineer, to some experiments conducted by Major General Uchatius* in Austria of firing under water. Uchatius, when reading in Jules Verne's "Twenty Leagues Under the Sea" how Capt. Meno, with his involuntary guests, sheltered in a diving bell, devoted himself to the pleasures of hunting, and how with a pneumatic gun at a depth of 10 meters he shot an albatross while flying a meter above the surface of the sea, asked himself the question—Is it possible as a general thing to shoot under water? And if this is so, why are not divers provided with fire-arms for defense against large fishes?

"It is known," says Uchatius, "that fishes can be shot, if they are not too deep under the surface of the water, from the land or boats. But it is also known that the covering of a war ship reaches at the most only 2 or 3 meters under the surface of the water, as below this depth the ship is considered invulnerable for the greatest hostile shots, since the latter can strike only under an angle at the greatest of 20 to 30 degrees, and consequently before their contact with the unprotected part of the ship must have passed through from 6 to 8 meters of water." The subject appeared sufficiently interesting to Uchatius to prompt him to conduct a series of experiments. Under a raft built of timber he fastened a rejected Austrian service rifle by means of iron spans, so that the gun when the raft floated on the water was held from 0·5 m. under the water in a horizontal position. The discharge was effected from the shore by means of a string. An inch plank was used as a target, which was sunk vertically in the water at a given distance from the mouth of the gun.

this rifle at 3 ft. 11½ ins., while with the U. S. army rifle the board had to be ¾ in. nearer the rifle, or at 3 ft. 10¾ ins., before it was penetrated, and when the Spanish model was used the board had to be 1½ in. nearer the rifle than in the first case, or at a distance of 3 ft. 10 ins. This relation was true for the cartridges used,* which were composed of 68 grains powder and 450 of bullet for the U. S. model, 90 grains powder and 542+ of bullet for the U. S. army rifle, and 72 grains powder and 384+ bullet for the Spanish model. The question naturally arose what would be the relation if cartridges for each rifle were composed of the identically same proportions of powder and bullet. This I considered a very important problem, and I therefore submitted the proposition to prepare 25 cartridges for each rifle, to contain exactly 70 grains of powder and 450 grains of bullet, to the Remington Sons, and they willingly volunteered to prepare them for me. It will be noticed from the above table that ¼ of an inch determined in every case whether the bullet was to penetrate the board or was to be imbedded. This may be considered a very short distance, but when we consider that water is 770 times denser than the air at 4° Cent., Bar. 29·922 ins. (Pres.=760 mm. of Hg.), one quarter of an inch under water is equivalent to over 16 feet through the air. If a cartridge contains sufficient force power to propel a bullet from a rifle through the air so that it will penetrate a board exactly 2,400 feet away, if the board were placed 2,416 feet it would not be difficult to conceive, instead of the bullet passing through the board, of its being imbedded. Precisely the same thing happens under water—the force power imparted to the bullet is quite sufficient to penetrate a board at 3 ft. 11½ ins. distant when the U. S. model rifle is employed, but the force expended in traveling ¼ of an inch further deprives the bullet of the necessary amount of force to penetrate the board. The preparing of the cartridges, as I have already stated, for further experiments was done for me by

I. THE NEW YORK STATE MODEL (or U. S. model) used at Creedmoor by the National Guard, ·50 caliber or 12·7+ mm. Barrel, 35½ in. (·9017 m. long.) The cartridges used were composed as follows:

TABLE NO. 1.

PARTS.	1.	2.
Weight of cartridge	676·119 grains= 43·81 grams.	679·360 grains= 44·02 grams.
" of powder	68·000 grains= 4·406 grams.	68·630 grains= 4·447 grams.
" of bullet	450·380 grains=29·170 grams.	450·489 grains=29·190 grams.
" of brass case	152·169 grains= 9·860 grams.	156·490 grains=10·140 grams.
" of paraffine	5·570 grains= ·374 grams.	3·751 grains= ·243 grams.
TOTAL	676·119 grains= 43·81 grams.	679·360 grains= 44·02 grams.

II. THE SPRINGFIELD MODEL (or U. S. Army Rifle). ·58 caliber (14·7 mm.). Barrel, 39½ ins. (1·0033 m.) long. The cartridges used were composed as follows:

TABLE NO. 2.

PARTS.	1.	2.
Weight of cartridge	778·579 grains=50·449 grams.	765·939 grains= 49·63 grams.
" of powder	90·000 grains= 5·838 grams.	84·727 grains= 5·490 grams.
" of bullet	542·627 grains=35·225 grams.	542·006 grains=35·120 grams.
" of brass case	131·026 grains= 8·49 grams.	129·328 grains= 8·380 grams.
" of filling* & paraffine.	14·926 grains= ·896 grams.	8·565 grains= ·555 grams. 1·313 grains= ·085 grams.
TOTAL	778·579 grains=50·449 grams.	765·939 grains= 49.63 grams.

*The bullets were hollow to half their height, the cavity being filled with a substance resembling white lead or putty.

III. THE SPANISH MODEL. ·433 caliber, or 11 mm. Barrel, 35½ in. (·9017 m.) long. The cartridges used were composed as follows:

TABLE NO. 3.

PARTS.	1.	2.
Weight of cartridge	605·1279 grains= 39·21 grams.	612·690 grains= 39·7 grams.
" of powder	72·4579 grains= 4·695 grams.	73·121 grains= 4·738 grams.
" of bullet	384·8990 grains= 24·94 grams.	388·988 grains=25·205 grams.
" of brass case	144·6070 grains= 9·37 grams.	147·848 grains= 9·580 grams.
" of paraffine	3·1639 grains= ·205 grams.	2·733 grains= ·177 grams.
TOTAL	605·1279 grains=39·210 grams	612·690 grains= 39·7 grams.

The results of Uchatius' experiments were as follows:
At a distance of 1·5 m. (4·90 feet)..........No impression.
" " 1·25 m. (4·10 feet)..Three to four mm. deep.
" " 1 m. (3·28 feet).................. Pierced.

According to these experiments a distance of 5 m. decided whether there was to be any impression or whether the board was to be pierced.

These experiments being of so original a nature, and seeing in them a means of arriving at a number of important results, I determined to verify the same, and elaborate upon them. Having already constructed a tank twelve feet (3·6576 m.) long by 9 feet (2·7432 m.) wide by 3 feet (9·144 m.) high, capable of holding over 10 tons (907·10528 kilgms.) of water, I had the sides securely bolted together by large beams of wood to prevent them from bursting out. I also had firmly constructed within the tank wooden rests for the guns to be used, so that there could be at least 15 inches of water over them if so desired. Being desirous to secure the best guns for experiment, I visited the office of the Remington Manufacturing Company, stated the object of my experiments, and Mr. A. Alford, the manager, kindly furnished me with guns and all the cartridges needed. My first experiments were conducted on the 22d of February, in the presence of Count Kolowrat, lieutenant of the Austrian army, Barnet Phillips of the New York *Times*, and A. Alford of Remington Sons. In my second experiments I was assisted by Mr. Frank Terry, Ph. B. Three breech-loading Remington rifles were used for the experiments. (See tables Nos. 1, 2, and 3).

The target consisted of a white pine board, 3 feet high, 10 inches wide, and one inch thick, and was securely nailed upright in the tank by means of braces, so as to afford perfect resistance to the bullet. The temperature of the water was 4° C., sp. gr. 1·000. The rifle was placed on the supports in the tank and loaded under water, and fired by inserting the hand and pulling the trigger. In the first few experiments the trigger was pulled by a string at a respectful distance. (See tables Nos. 4, 5, 6, and 7).

From Table No. 7 it will be seen that the U. S. model is far superior to the other rifles. A board was penetrated with

*Mittheilungen uber Gegenstande des Artillerie und Genie-Wesens, Vol. XIII., pp. 53, 54.

the Remingtons. In making the cartridges for the U. S. army rifle, the shell being made for 90 grains of powder was too large for 60 grains, and consequently there would be an air chamber between the bullet and the powder, if wadding were not placed between. The first cartridges made for me contained this air chamber, but as I was of the opinion that the same amount of force power would not be communicated so effectually to the bullet if the powder was in a loose state as it would be if it were packed, the Remingtons made me other cartridges with the powder packed with a paper wad, although Mr. Alford stated to me that it was the impression of sportsmen that there would be no difference. I decided therefore to test this point by actual experiment. To prepare cartridges for the Spanish model would involve considerable extra expense. I therefore concluded to substitute a Sharps rifle of ·50 caliber. The cartridges were composed as follows: (See table No. 8.)

Tables No. 9, 10, 11, and 12 contain the report of my experiments conducted with the new cartridges on May 4, '78, the temperature of the water being 19° C., or 66·2 F.

On carefully examining the figures in this table we will see that when the U. S. model rifle or Sharps rifle was employed, exactly the same results were obtained, that is to say, the board would be penetrated at a distance of 4 ft. 1½ in., while in the case of the U. S. army rifle, with packed cartridges, the board had to be 1⅞ inch nearer the rifle, or at a distance of 3 ft. 9⅝ inches, one inch and seven eighths through water being equivalent to 120·31 ft. through the air. It is therefore plain that the U. S. army rifle is very inferior to the other two. Even with 90 grains of powder and 542+ grains of bullet, as shown by table No. 7, it is greatly inferior to the U. S. model.

On examining the shape of the bullets employed I found that, while the bullet used in the cartridges for both the U. S. model and Sharps rifle were quite conical, those employed in the cartridges for the army rifle were quite blunt. Fearing that the shape of the bullet offered some resistance to its progress, I carefully cut the bullets of the army rifle cartridges quite conical, and on experimenting found that only a difference of ⅜ of an inch in several experiments was made—that is to say, when the blunt bullet was used, the

*See Tables.

board was penetrated at 3 ft. 9⅝ ins., and when the conical bullet was used, at 3 ft. 10 ins.

When cartridges were used containing the powder loose, by examining Table 12 it will be seen that the results are very variable, and that the board had to be 1⅛ in. nearer the rifle before it could be penetrated. In Table No. 13 are given the results of the four rifles used for experiment, compared with the Austrian rifle.

It will be seen from this table that the U. S. model rifle (N. Y. State model) and Sharps rifle come first; then the U. S. army rifle; next the Spanish model; and last the Austrian service rifle. The experiments made by Uchatius with this last rifle were very limited—as for example he did not determine the distance that established the fact whether the bullet is to penetrate the board or is to be imbedded; he consequently did not arrive at the true value of the rifle as regards penetration, and as the weight of powder and bullet were not given in his report, it is hardly fair to consider the Austrian rifle on such data inferior to the rifles I experimented with, until more exact experiments are conducted with it. It now becomes necessary to investigate into the cause of the variance between the different rifles experimented with. It will be remembered in the first part of my paper I stated my object was to verify the experiments of Uchatius. I therefore adopted the conditions under which he worked as much as possible, as for instance he says: "The distances were measured from the *mouth* of the gun." From the description given of each rifle I experimented with, it will be seen that the length of barrel differed—that is to say, while the length of barrel for the U. S. army rifle was 39⅛ inches, that of the U. S. model and Spanish model was 35⅛ ins., while that of the Sharps rifle was only 30⅛ inches. It will be evident, as all my measurements were taken from the end of the barrel, instead of from the end of the cartridge, that the bullet in the barrel having the greatest length had to travel through more water (in the barrel) than a barrel of a less length. (See illustrations, page 2017).

From the illustration it will be seen, supposing the cartridges to be all of the same length, that the bullet in the U. S. army rifle had to travel through (39⅛–35⅛) 4 inches more water than the U. S. model rifle, and that the bullet from the Sharps rifle did not have to travel by (35⅛–30⅛) 5 inches as much water as the bullet of the U. S. model rifle. Correction must therefore be made before any true comparison of the rifles can be made. With respect to the cartridges some correction must be made, as they are not of the same length. (See illustration, page 2017).

It is evident if the measurements are to be taken from the cartridge, they must be from that part of the cartridge which fits the barrel and not from the end of the bullet. As the bullet has a more or less conical shape, it is therefore

Experiment with Rifle No. II. (U. S. Model Rifle.)

TABLE NO. 4.

NO. OF SHOTS.	AT A DISTANCE OF	REMARKS.	HEIGHT OF WATER OVER RIFLE.
1	2 feet 0 inches	The board was penetrated	8¾ inches.
2	2 " 6 "	" " "	" "
3	3 " 0 "	" " "	" "
4	3 " 8 "	" " "	" "
5	3 " 9 "	" " "	" "
6	3 " 10½ "	" " "	" "
7	3 " 11 "	" " "	" "
8	3 " 11¼ "	" " "	12½ "
9	3 " 11½ "	" " "	" "
10	3 " 11½ "	" " "	" "
11	3 " 11¾ "	The bullet was imbedded	" "
12	3 " 11¾ "	" " "	" "
13	4 " 0 "	¼ inch indentation	" "
14	4 " 0 "	¼ " "	" "
15	4 " 8 "	⅛ " "	" "
16	4 " 8½ "	⅛ " "	" "
17	4 " 10½ "	1/16 " "	" "
18	4 " 11½ "	Indented	" "
19	4 " 11¾ "	No mark	" "
20	5 " 0 "	"	" "

Experiment with Rifle No. II. (U. S. Army Rifle.)

TABLE NO. 5.

NO. OF SHOTS.	AT A DISTANCE OF	REMARKS.	HEIGHT OF WATER OVER RIFLE.
1	3 feet 3 inches	Board was penetrated	5½ inches.
2	3 " 5 "	" "	" "
3	3 " 6 "	" "	7 "
4	3 " 9 "	" "	6 "
5	3 " 10 "	" "	" "
6	3 " 10¼ "	" "	" "
7	3 " 10½ "	" "	" "
8	3 " 10¾ "	" "	12½ "
9	3 " 10¾ "	" "	" "
10	3 " 11 "	" imbedded	" "
11	3 " 11 "	" "	" "
12	4 "	" "	6 "
13	4 "	" "	5¾ "

Experiment with Rifle No. II. (Spanish Model Rifle.)

TABLE NO. 6.

NO. OF SHOTS.	AT A DISTANCE OF	REMARKS.	HEIGHT OF WATER OVER RIFLE.
1	3 feet 7¾ inches	Board was penetrated	5½ inches.
2	3 " 9¾ "	" "	" "
3	3 " 10 "	" "	12 "
4	3 " 10¼ "	Bullet deeply imbedded	" "
5	3 " 10½ "	Imbedded	" "
6	3 " 10¾ "	"	7 "
7	3 " 10¾ "	"	7 "
8	3 " 11 "	¾ inch indentation	12 "
9	3 " 11½ "	½ " "	7 "
10	4 " ¼ "	½ " "	7 "
11	4 " 1¾ "	½ " "	7 "
12	4 " 2 "	Slightly imbedded	12 "
13	4 " 3½ "	½ inch indentation	" "
14	4 " 5 "	Slightly imbedded	" "
15	4 " 5½ "	¼ inch indentation	" "
16	4 " 5¾ "	⅛ " "	" "
17	5 " — "	1/16 " "	" "
18	5 " ½ "	1/16 " "	" "
19	5 " 2 "	No mark	" "

The principal points of the above tables may be tabulated in a condensed form as follows:

TABLE NO. 7.

NO. OF SHOT.	AT A DISTANCE OF	IN METERS.	REMARKS.	DEPTH OF WATER.
9 & 10	*The U. S. Model* 3 ft. 11½ in.	1·2019	Board was penetrated	12½ inches.
11 & 12	" " 3 ft. 11¾ in.	1·2074	Bullet was imbedded	" "
19	" " 4 ft. 11¾ in.	1·5122	No mark	" "
8 & 9	*The U. S. Army Rifle* 3 ft. 10¾ in.	1·182	Board was penetrated	" "
10 & 11	" " " 3 ft. 11 in.	1·1894	Bullet was imbedded	" "
3	*The Spanish Model* 3 ft. 10 in.	1·1644	Board was penetrated	12 "
4	" " 3 ft. 10¼ in.	1·1704	Bullet was imbedded	" "
19	" " 5 ft. 2 in.	1·574	No mark	" "

TABLE NO. 8.

PARTS.	I. Cartridges for ·50 caliber.		II. Cartridges for ·58 caliber.		III. Cartridges for ·58 caliber.	
	Grains.	Grams.	Grains.	Grams.	Grains.	Grams.
Weight of cartridge	648·03	41·99	669·94	43·410	695·43	45·061
" of powder	70·22	4·55	69·91	4·53	70·19	4·548
" of bullet	450·18	29·17	449·75	29·142	447·85	29·019
" of shell	126·55	8·20	147·23	9·54	161·82	10·485
" of paraffine	1·08	·07	3·05	·198	1·76 / 13·81	·114 / *·895
TOTAL	648·03	41·99	669·94	43·410	695·43	45·061

*Wad.

Experiments with U. S. Army Rifle No. II.

TABLE NO. 9.

NO. OF SHOTS.	Using cartridges with powder packed, at a distance of	Using cartridges with powder loose, at a distance of	REMARKS*	Height of water over rifle.
1	3 feet 10 inches		¼ inch indentation	11½ inches.
2		3 feet 10 inches	1/32 inch indentation	" "
3	3 feet 9⅝ inches		Penetrated the board.	" "
4		3 feet 9⅝ inches	Imbedded	" "
5		3 feet 9⅝ inches		
6, 7	3 feet 9¾ inches		Imbedded	" "
8		3 feet 9¾ inches	¼ inch indentation	" "
9		3 feet 9½ inches	Completely imbedded	" "
10		3 feet 9⅜ inches	Imbedded	" "
11		3 feet 9¼ inches	Imbedded	" "
12, 13		3 feet 9 inches	Deeply imbedded	" "
14		3 feet 8¾ inches	Almost through	" "

*Quite a difference in effect will be noticed between the same cartridges in column two of the table, owing to the powder being loose.

Experiment with a Sharps Rifle. ·50 caliber, or 12·7 mm. Barrel, 30⅛ ins. The cartridges used have the composition shown in Table No. 8, column No. 1.

TABLE NO. 10.

NO. OF SHOTS.	AT A DISTANCE OF	REMARKS.	HEIGHT OF WATER OVER RIFLE.
1	3 feet 10 inches	Penetrated the board	11½ inches.
2	3 " 11½ "	" "	" "
3	3 " 11¾ "	" "	" "
4	4 " ½ "	" "	" "
5	4 " 1 "	" "	" "
6	4 " 1½ "	" "	" "
7	4 " 1¾ "	Deep indentation	" "
8	4 " 2¼ "	¼ inch indentation	" "

Experiments with U. S. Model Rifle.

TABLE NO. 11.

NO. OF SHOTS.	AT A DISTANCE OF	REMARKS.*	HEIGHT OF WATER.
1	4 feet	Penetrated the board	11½ inches.
2	4 feet 1½ inches	" "	" "
3	4 feet 1¾ inches	Imbedded	" "
4	4 feet 2 inches	"	" "

*Same cartridges as used for Sharps Rifle.

Tabulating the principal points in the above tables, we find:

TABLE NO. 12.

NO. OF SHOT.	RIFLE.	AT A DISTANCE OF	IN METERS	REMARKS.	DEPTH OF WATER.
				(Powder packed.)	
3	U. S. Army Rifle	3 feet 9⅝ inches.	1·1589	Board was penetrated	11½ in.
6 and 7	" "	3 feet 9¾ inches.	1·1620	Imbedded	"
				(Powder loose.)	
*	" "	3 feet 8½ inches.	1·1303	Board penetrated	"
14	" "	3 feet 8¾ inches.	1·1366	Deeply imbedded	"
6	Sharps Rifle	4 feet 1½ inches.	1·2573	Board was penetrated	"
7		4 feet 1¾ inches.	1·2636	Deeply indented	"
2	U. S. Model	4 feet 1½ inches.	1·2573	Board was penetrated	"
3		4 feet 1¾ inches.	1·2636	Imbedded	"

*As the cartridges run out I was unable to try this experiment, but as the bullet was almost through at 3 ft. 8¾ ins., my experience tells me that at 3 ft. 8½ ins., the bullet would have penetrated the board.

TABLE NO. 13.

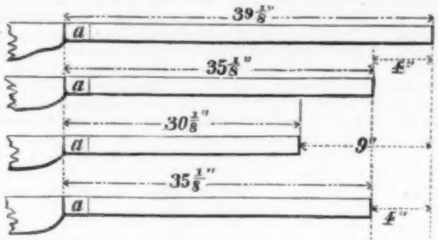
NAME OF RIFLE.	PENETRATED THE TARGET AT	WEIGHT OF POWDER.	WEIGHT OF BULLET.	REMARKS.
U. S. Model	3 feet 11½ inches	68+grains.	450+grains.	See tables 7 and 1.
U. S. Model	4 feet 1½ inches	70 grains.	450 grains.	See tables 11 and 8.
Sharps Rifle	4 feet 1½ inches	70 grains.	450 grains.	See tables 10 and 8.
U. S. Army Rifle	3 feet 10¾ inches	90 grains.	542+grains.	See tables 7 and 2.
U. S. Army Rifle	3 feet 9⅝ inches	70 grains.	450 grains.	See tables 9 and 8.
Spanish Model	3 feet 10 inches	72+grains.	384+grains.	See tables 7 and 3.
Austrian Rifle	3 feet 3⅜ inches	? grains.	? grains.	By Uchatius.

TABLE NO. 14.

RIFLE.	AT A DISTANCE OF	(CORRECTED.) AT A DISTANCE OF	REMARKS.
U. S. Army Rifle	3 feet 9⅝ inches.	4 feet 1 1/16 inches.	Board was penetrated.
U. S. Army Rifle	3 feet 9¾ inches.	4 feet 1 4/16 inches.	Bullet was imbedded.
U. S. Model Rifle	4 feet 1½ inches.	4 feet 1½ inches.	Board was penetrated.
U. S. Model Rifle	4 feet 1¾ inches.	4 feet 1¾ inches.	Bullet was imbedded.
Sharps Rifle	4 feet 1½ inches.	3 feet 8½ inches.	Board was penetrated.
Sharps Rifle	4 feet 1¾ inches	3 feet 8¾ inches	Bullet was imbedded.
*Spanish Model	3 feet 10 inches.	3 feet 10 3/16 inches	Board was penetrated.
*Spanish Model	3 feet 10¼ inches.	3 feet 10 7/16 inches	Bullet was imbedded.

*The powder in this case was 72-73 grains; bullet, 384-388 grains.

surrounded by water when the rifle is submerged. In the case of the cartridges for the U. S. army, U. S. model and Sharps rifle, the end of the metallic case is the proper point for measurement. In the case of the cartridge for the Spanish model the measurement must be from that point of the case just before it becomes beveled to a smaller circumference. Regarding these points, we find from the illustrations that the case of the U. S. army cartridge is $\frac{2}{32}=\frac{1}{16}$ inch less than the U. S. model, and in the case of the cartridge for the Spanish model the point of measurement is $\frac{6}{32}=\frac{3}{16}$ inch less than that of the U. S. model. The proper correction then to make in the case of the U. S. army rifle is 4 inches ($39\frac{1}{8}$–$35\frac{1}{8}$) for the barrel and $\frac{1}{16}$ in. for the case, or total $4\frac{1}{16}$ inches. For the Sharps rifle 5 ins. ($35\frac{1}{8}$–$30\frac{1}{8}$) is the total correction, as the same cartridge is used for U. S. model. For the Spanish rifle, the barrel being the same as that of the U. S. model, the only correction will be for cartridge, or $\frac{3}{16}$ inch=total correction. Making the above corrections in the results obtained with equal weight of powder and bullet for each rifle measured from the mouth or muzzle of the gun, we obtain the true relation of one rifle to another, which will at once be seen to be a great deal different from the first results. (See Table No. 14.)



U. S. Army Rifle—·58 *Caliber.*

U. S. Model Rifle—·50 *Caliber.*

Sharps Rifle—·50 *Caliber.*

Spanish Model Rifle—·433 *Caliber.*

a—Cartridge.

By examining the corrected results in the second column of Table No. 14 it will be seen that the *U. S. Army Rifle* is superior by $\frac{3}{16}$ in. to the U. S. model rifle, and that the U. S. model rifle is 5 inches superior to the Sharps rifle. Calculating for each rifle at what distance a board would be penetrated if the bullet passed through the air instead of water, we find (see Table No. 15, below.)

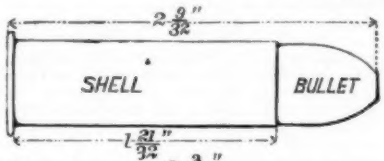
TABLE NO. 15.

RIFLE.	THROUGH WATER AT A DISTANCE OF	REMARKS.	THROUGH AIR AT A DISTANCE OF	REMARKS.
U. S. Army Rifle.	4 feet $1\frac{11}{16}$ inches.	Board penetrated..	3182·54 feet.	Board would be penetrated.
U.S. Model Rifle.	4 feet $1\frac{1}{2}$ inches.	" "	3176·25 feet.	"
Sharps Rifle. ..	3 feet $8\frac{1}{2}$ inches.	" "	2855·41 feet.	"
Spanish Model	3 feet $10\frac{}{16}$ inches	" "	2962·13 feet.	"

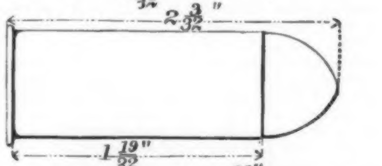
From this table it will be seen that the bullet from the U. S army rifle will penetrate a board through the air at 6·29 feet further than when the U. S. model is used, and 327·13 feet further than when the Sharps rifle is used, with the same weight of powder and bullet. In conclusion I would remark that there can be no doubt, if the subject of firing submerged guns is understood and appreciated, that in the future, when an arm is to be tested, instead of firing it in the air it will be fired under water, and, as the editor of the *Forest and Stream* states, "long ranges for testing rifles will be supplanted by water tanks." With respect to the tank a word or two may be of advantage. It should be about 12 feet long by 2 feet wide by 3 feet high, and if made of wood the wood must be at least 2 inches thick, and the sides securely bolted together. As water is only very slightly compressible it will at once be understood that when the gun is fired the force of the explosion is at once communicated to the sides of the tank, and unless they are securely bolted they will be readily broken apart. The tank could be made of iron or could have heavy plate glass sides in an iron frame, when the bullet could be seen to drop.

By this method of investigation, range and penetration can be arrived at with the greatest precision—also the value of the numerous gunpowders on the market can be accurately arrived at, as well as the maximum effect from the minimum amount of powder, the best weight of bullet for a given weight of powder, the best length of barrel and size of bore for a given weight of powder and bullet, and the actual range of a given cartridge. All these observations can be carried on in a room less than 12 feet square. The height of water over the rifle according to my experiments makes no difference; that is to say, the same results were obtained when the rifle was submerged 5 inches as when submerged 12 inches. This is not singular when we consider the rapidity with which the bullet travels and the short space of time the column of water has to act on it. The cause of the limited range under water then is due to the motion of the bullet being opposed by a medium of a much greater density than that of the atmosphere. The cause of the variance between different rifles from my experiments I have been led to believe is due to the differences in length of barrel, to the size of bore and internal structure of barrel, but more particularly to the fact that as a rule the amount of powder and bullet are not only in absurd relations to each other but are not in correct proportions for the length and bore of barrels peculiar to different rifles, which only demonstrates that there are a vast number of very important points yet to be unfolded.

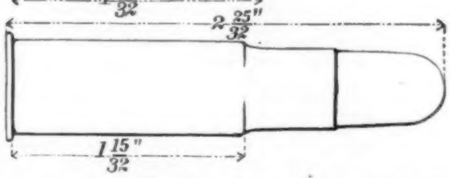
CARTRIDGES.



U. S. Model and Sharps Rifle.



U. S. Army Rifle.



Spanish Model Rifle.

IMPROVED WHITE GUNPOWDER.

A NEW explosive agent has been discovered by Prof. Emerson Reynolds, Professor of Chemistry, Trinity College, Dublin. It is a mixture of 75 per cent. of chlorate of potassium with 25 per cent. of a body called sulphurea. It is a white powder, which is very easily prepared by the mixture of the materials in the above-named proportions. The new powder can be ignited at a rather lower temperature than ordinary gunpowder, while the effects it produces are even more remarkable than those caused by the usual mixture. Dr. Reynolds states that his powder leaves only 45 per cent. of solid residue, whereas common gunpowder leaves about 57 per cent. It had been used with success in small cannon, but its discoverer considered that its chief use would be for blasting, for shells, for torpedoes, and for similar purposes. Dr. Reynolds pointed out that one of the advantages this powder possesses is that it can be produced at a moment's notice by a comparatively rough mixture of the materials, which can be stored and carried without risk so long as they are separate. The sulphurea, the chief component of the new explosive, was discovered by Dr. Reynolds about ten years ago, and could be easily procured in large quantities from a product of gas manufacture which is at present wasted.

MEMORANDA RELATING TO CONDENSATION.

A SERIES of experiments were made at the boiler works of Messrs. McCurdy & Warden, West Street, N. Y., during the months of March and April, 1878, under the supervision of Wm. Rogers, assisted by Joseph Belknap and Wm. Burnett, engineers, the object of which was to accurately determine the quantity of water of condensation made in a given time by one square foot of exposed steam heated surface; what proportion of this condensation could be prevented by insulating this surface with felting; also to ascertain the comparative value, as insulators, of the various kinds of material now in use.

The apparatus upon which these experiments were made consisted of three wrought iron cylinders, made water and steam tight, and placed in a vertical position upon a platform, with about 20 inches of space between each. These cylinders exposed a surface of nearly five square feet each—were five inches internal by five and a half inches external diameter. A glass water gauge was attached to the lower end of each cylinder, through which the water could be observed, measured, and drawn off. A steam gauge was also attached to the apparatus. The three cylinders could be operated together or separately at pleasure. Steam was admitted at the tops of the cylinders through small pipes leading direct from the boiler.

It being necessary, before any useful results could be obtained, to become assured that the quantity of water of condensation found in each cylinder was that due to its exposed surface, and no more, repeated trials and experiments continued for several days were made, which proved that no water from the boiler, nor condensation in the connecting pipes, found its way into them, and that the quantity of condensation was the same in each, whether operated together or separately.

Each trial on the apparatus was continued one hour, and observations as to the increase of water, pressure of steam, and temperature of the surrounding atmosphere were made and mended every ten minutes.

The mean steam pressure in cylinders equaled 53 pounds to the square inch.

The mean temperature of the surrounding atmosphere equaled 60° Fah.

It was observed that the condensation increased or decreased in the same ratio as the pressure and temperature of the steam increased or decreased, but that the slight changes which occurred in the temperature of the atmosphere did not very perceptibly affect the result.

The condensing power of this apparatus, of course, decreased as the water increased in the cylinders, consequently the insulated cylinders labored under some disadvantage from this cause.

A mean of all the trials made on the apparatus, with the three cylinders exposed, showed $6\frac{1}{2}$ inches of water in each gauge, equal to 127·63 cubic inches made by each cylinder in one hour.

A mean of all the trials made after insulating one of the cylinders with cotton seed hulls, two inches in thickness, showed the same results on the exposed cylinders as before, while the insulated cylinder only made $1\frac{1}{4}$ inch, equal to 24·54 cubic inches in one hour.

The result in every case was the same whether the cylinders were operated together or separately.

It will be understood that the only circulation was that caused by the condensation of the steam in the cylinders, but to show the effect a more rapid circulation would have, a pipe was inserted in one of the exposed cylinders, with the end leading into the open air, and leaving this pipe open while operating the apparatus only affected the result to the extent of a trifling increase of water in the cylinder having this attachment.

According to these tests and experiments, one square foot of steam heated surface, $\frac{1}{4}$ of an inch in thickness, steam pressure 53, atmospheric temperature 60°, will make 25·53 cubic inches of water in one hour. The same surface insulated by cotton seed hulls will only make 4 9 cubic inches of water in the same time, equal to 81 per cent. saved.

The question now recurs: Can this data—these facts—be made of practical value? Can a rule or formula be so expressed that any one can calculate the loss by condensation from exposed steam-heated surfaces, and the economic value of insulating such surfaces by felting, for any number of square feet, at any pressure of steam and atmospheric temperature?

Suppose the difference between the temperature due the pressure of the steam used and that of the atmosphere be multiplied by 25·53, this product divided by 223, and this result multiplied by the number of square feet exposed; this product will equal the cubic inches of water made in one hour.

Now substitute 4 9 in place of 25·53 in the above; proceed as before, and then subtract this last product from the first; the remainder will equal the volume of steam at the pressure used, saved for useful work, their cubic inches of water made; and the proportion this quantity of water bears to the whole amount evaporated represents the economic value of insulating steam-heated surfaces, or, in other words, the saving in fuel.

To express the above algebraically, let

A = differential temperature of steam used.

25·53 = cubic inches per hour per square foot of exposed surface, at steam pressure 53, atmospheric temperature 60°.

4·9 = cubic inches per hour per square foot of insulated surface.

223 = differential temperature of steam, pressure 53, atmospheric temperature 60° Fah.

B = cubic inches per hour per square foot.

C = number square feet exposed surface.

D = cubic inches water of condensation made in one hour.

Then

$\frac{A \times 25\cdot53}{223} = B$, and $B \times C = D$ cubic inches due exposed surface. And

$\frac{A \times 4\cdot9}{223} = B$, and $B \times C = D$ cubic inches due insulated surface.

The difference between the two values of D in the above equals the condensation prevented, and represents the economic value, as in the first statement.

It will be noticed that the above rules are based on temperature, and that density is not considered. But making the density of the steam a factor in their calculation, as well as its temperature, will increase somewhat the economic value of insulating exposed surfaces. It is intended to continue these experiments at higher pressure, when the effect of density as well as that of a greater or less thickness of surface will be more fully demonstrated.

In all the experiments made with cotton seed hulls, with reference to their efficiency in lessening the loss from radiation, it has invariably been found that at 50 pounds pressure, equal to 279° Fah., the outside of the hulls indicated 80°, equal to 71 per cent. saved, and at 100 pounds pressure, equal to 332° Fah., the outside of the hulls indicated 90°, equal to 73 per cent. saved.

The relative value of other materials as insulators for steam-heated surfaces cannot be given here, for the reason that no opportunity was offered to test them, except hair, which is known to be quite equal to cotton seed hulls when it is of the very best quality.

The apparatus upon which these experiments were made will be for the present at No. 277 West Street, N. Y., where no doubt any one wishing to do so can secure the privilege to test other materials with it.

MR. ALBERT BORSIG, the well-known locomotive engineer, of Berlin, died on the 10th of April, at the early age of 49. The works were founded by his father in 1837, and since the beginning have turned out over 3 600 locomotives for Germany, Russia, Sweden, Denmark, Holland, and Austria, and for the Dutch colonies. Mr. Borsig was one of the largest employers of labor, the number of his workmen at his Berlin works and at his iron and steel works and coal mines in Silesia exceeding 10,000. How successfully the works have been carried on is shown by the fact that Mr. Borsig's father began work with a capital of £1,500 lent to him by a Berlin tradesman, and that the son died one of the wealthiest men in Germany, having left property worth about £3,000,000 sterling.

MODERN BLASTING EXPLOSIVES.

At no period in the history of the civilized world has the adage "Time is money" been more forcibly illustrated than in the actual demand by the mining community for the strongest explosives—or, in other words, for the explosive which will produce the greatest effect with the smallest labor or time employed in boring holes to receive the same, or in tamping. Again, the military engineer keeps himself *au fait* of all new destructive agents which, under the smallest weight, will do the most mischief, the most essential point in using explosives in the field being to place the charge on the proper spot at the proper time, which means quick carriage and hence small weight. Chemistry and engineering have not been slow to respond to the demand, and among the host of explosives which have been brought forward at different times there are some two or three which have attained a decided pre-eminence, each in its way. We refer to dynamite, tonite, and compressed gun-cotton.

The literature of modern explosives exists only in the shape of papers read at institutions and pamphlets from scientific specialists. We will endeavor in the following lines to gather a few notes which we believe may be of some value both to the scientific and the practical man. It is not our intention to dwell at length on what might be called the earlier history of the explosives under consideration. We will only call to mind the points of interest which have marked their progress toward practical utility. It is well known that gun-cotton was first introduced to the public by Schonbein in 1846. Great things were expected from the discovery, and yet in a few years, after a brief but eventful career, gun-cotton was relegated to the laboratory shelf, and among the sufficient causes for such a proceeding we may mention the inability of the makers to produce a stable article, and also the enormous bulk occupied by a charge of the explosive, as well as its inherent property of disengaging upon explosion a large amount of carbonic oxide gas, which, in close workings, is not only objectionable on account of health, but absolutely dangerous as fire damp. Ways and means as ingenious as numerous were tried in divers countries to master this promising but crude invention, but the only improvement, partially successful, was for a long time obtained in nitrating the gun-cotton with saltpeter. This material reduced the carbonic oxide and added considerably to the strength of the gun-cotton, but the fumes resulting must have been very inconvenient, as the carbonate of potassa produced very readily remains in suspension in the atmosphere for a long time, not to mention the almost inevitable presence of cyanide of potassium, but the most potent objection to its use was its liability to explode spontaneously.

Things were in this condition, and ordinary gunpowder continued to reign supreme, when Sobrero somewhat before 1830 introduced his nitro-glycerine. New hopes were raised, and as a consequence money, labor, and ingenuity were devoted to the work, but nitro-glycerine, like gun-cotton and indeed all great inventions, had a hard fight before it could inspire confidence in the public, for the material as then made was very unstable, and even when pure—chemically stable, if we may use that expression—it was liable to disruption from physical causes. One of these, still unexplained, happens during the passage of the frozen nitro-glycerine from the solid to the liquid state, as if the crystals were suddenly broken by a too sudden application of heat, as in the well-known decrepitation of common salt; a similar theory has been used to explain explosions which sometimes occur with fulminate of mercury when this substance is put to dry, which, although quite pure, may explode at a temperature far below its normal exploding point.

Now we come to one of the important epochs of invention—the discovery of dynamite by Mr. Alfred Nobel. Dynamite is nitro-glycerine mixed with an earthy absorbent, the result being a plastic instead of a liquid substance, and therefore more manageable, the tendency of the nitro-glycerine to spontaneous explosion in thawing being considerably reduced by reason of the modification in the structure of the compound. The nitro-glycerine used in the manufacture of dynamite can now be made quite pure, so the enormous consumption of the product is justified in the absence of any competing explosive. Let us hope that Mr. Nobel will by his intended new admixture entirely destroy the causes which bring about the terrible calamities frequently reported in the papers, such as that at Parma, and at Bangor quite recently, where dynamite exploded while being thawed. During the period of the progressive success of nitro-glycerine and dynamite, gun-cotton had a hard struggle for existence, the best if not almost the only friend of the latter substance being Prof. Abel, F.R.S., who with a clear practical mind, recognizing that no inherent property of gun-cotton stood in the way of its practical employment, set himself to solve the problem of its utilization. First he cut the gun-cotton fiber into pulp, thereby reducing its bulk and improving the stability of the gun-cotton by permitting a more thorough washing. It was then found that the power of exploding by a flame was very much reduced, in consequence of the closer texture of the compressed dry pulp, but as Mr. Nobel had successfully applied the detonator to his dynamite, so did Mr. Brown, of Woolwich, succeed in producing a first-class explosion with gun-cotton thus detonated.

These are splendid achievements, and the next step—nitrated pulped gun-cotton—was actually making its appearance when occurred the Stowmarket calamity, which drove all confidence away for a time. It was then proposed to use the pulped and compressed gun-cotton in the wet state, as it was found that it could be exploded in this condition by using a strong primer of dry gun-cotton; indeed, large quantities are now being employed under this condition, but of course all thoughts of using a nitrate with it were abandoned, as saltpeter does not answer in conjunction with wet gun-cotton. This was very regrettable, as it is well known that by nitrating gun-cotton its strength, as measured by the best energy it can produce, is increased fully 30 per cent., and, moreover, no carbonic oxide is produced—a very important item in ill-ventilated workings. Unnitrated and wet compressed gun-cotton is mainly used for military and naval purposes, on account of its safety over dynamite and its remaining unaltered by climatic changes; at all events, it is relatively easier to keep it from freezing. Miners, however, who buy explosives for profitable purposes, will not use it in any quantity. There remained, therefore, ample room for further progress in dry nitrated gun-cotton compressed to the smallest bulk. This has been obtained in an explosive called tonite, manufactured by the Cotton Powder Company of Faversham. The remarkable results obtained by the officials of that company in producing this explosive renders unnecessary any apology on our part for explaining at some length what these results are, and how much the mining community, and, indeed, the nation, may be benefited by their labors. About 1873 the Cotton Powder Company, under a somewhat different name, commenced operations, their object being, among other things, to produce nitrated gun-cotton according to the terms of their license, and commencing so soon after the great catastrophe at Stowmarket, it required no small amount of courage to attempt the manufacture of apparently a similar explosive, although it offered a most promising reward to success.

Tonite or cotton powder is now well known to all mining engineers under the shape of a dense dry cartridge; it is generally water-proofed, and is not altered by any conditions of temperature. The density of tonite is about 1·50—that is, it goes into the same space as dynamite, and in about two-thirds that of compressed gun-cotton. The base of tonite being gun-cotton, the first care of the manufacturers was to devise practical means of purifying that substance, which being produced of ordinary cotton steeped in mixed sulphuric and nitric acids contains in its crude state some portion of that mixture, with other nitro compounds. The free acids are easily eliminated by washing with water, with or without alkaline addition, but the nitro compound impurities—nitro-starch, nitro-glycerine, and other products of the resins, sugar, and impurities of the original cotton—are not so easily got rid of, being insoluble, and partly imprisoned in the capillaries of the cotton fiber. It had been long known to the chemical student that inferior nitro compounds are partly destroyed in boiling water, and that ammonia is a very powerful reducing agent of these compounds. It only needed practical hands to unite the processes. As the washing plant now stands at Faversham any quality of gun-cotton can be purified as to its dangerous impurities in about two hours, and the same process applies whether the fiber is very long or very short. This process has been in operation for about five years with perfect success, and we understand that it is partly followed at the Government works at Waltham Abbey. It can at all events be assumed that Professor Abel has satisfied his mind about the value of such washing or boiling process, for it will be remembered that at the last meeting of the British Association, at Portsmouth, he said that gun-cotton could now be made quite reliable.

From pure gun-cotton to dry nitrated powder there is only one step—choose the proper nitrate. Before settling this point we may dismiss chlorate of potash, the most powerful of all available oxidizing agents. It is known that gun-cotton used with the proper quantity of chlorate of potash is superior as a blasting agent to the best nitro-glycerine, but, like this substance, it is liable to explode under the slightest rough usage. The available nitrates for mixing with gun-cotton are the nitrates of ammonia, potassa, soda, baryta, strontia, etc. The nitrates of ammonia, soda, and to a certain extent strontia, are deliquescent, and have never been used with any success for a length of time; all these nitrates except that of baryta are very soluble, and thereby interfere with the manufacture, and, moreover, give very disagreeable fumes in the mines. In short, after many trials nitrate of baryta was definitely chosen. *Prima facie* it is the best suited to the purpose, as containing more earthy base in a given weight, but if we bear in mind that in mining the space occupied by the explosive is more an object than its actual weight, and as it is possible by the use of nitrate of baryta to lock up under the very smallest possible space a larger amount of energy than by the employment of any other nitrate, the choice then appears justified. There is another point to be considered in favor of tonite—its economy of manufacture. Tonite can be made at 40 to 50 per cent. less cost than gun-cotton, and of 30 per cent. greater strength. In these times of heavy military and naval expenditure it might be well worth considering what would be the economy to the nation in substituting tonite for ordinary wet gun-cotton, considering that the former is quite as safe, if not safer, than the latter, for wet gun-cotton stored in South America has lately given cause for serious doubts as to its stability.

We have said enough for the present to show that the question of a blasting agent is being vigorously studied, and that progress has been made; there are, however, a great many other very important points which will suggest themselves to the consumer, such as those under the head of plastic explosives *v.* solid cartridges, etc. These have been well tested, every experiment conforming with those thermodynamic theories which teach us that heat alone is force irrespective of space, and as the miner's chief object is to economize space, to minimize his boring, and the issue as between solid tonite and plastic dynamite is only about 5 per cent. of space, when all the pleas are considered, the question may be pronounced practically settled against dynamite in favor of its younger cousin tonite, against the daughter of nitro-glycerine in favor of the offspring of gun-cotton.—*Mining Journal.*

THE HUELVA PIER.

At a recent meeting of the Institution of Civil Engineers, the paper read was on "The Huelva Pier of the Rio Tinto Railway," by Mr. T. Gibson, Assoc. Inst. C. E.

The cupriferous iron pyrites mines of Rio Tinto, in the South of Spain, were very ancient, having been worked by the Romans. Their output last year amounted to 750,000 tons. The mines were situated about fifty miles from the Port of Huelva, which port was about twelve miles from the bar of the River Odiel. There being no accommodation at the port for shipping, the traffic was formerly conveyed between the vessels and the beach by barges and small craft, a mode of shipment manifestly only suited for a small trade. It therefore became necessary to provide a cheaper and more expeditious plan of shipping minerals. The banks by the side of the river were scarcely 2 ft. above high water, and were principally marsh land, the substratum consisting of soft blue clay for more than 80 ft. in depth, and extending into the bed of the river. When the natural formation of the harbor, the depth of water, the rise and fall of the tide, and other points had been fully considered, it was resolved to construct a pier upon screw piles. Advantage was taken of the methods in use for the shipment of minerals at most of the large shipping ports in England, especially those adopted by Mr. Harrison, past-president of the Institution of Civil Engineers, at the Tyne Docks.

The important question was whether the roadway of the pier should be a comparatively small height above high water, and the wagons be lifted by hydraulic or some other power to an elevation sufficient to admit of the contents being tipped into the hold of the vessel, or whether the pier should be built upon a rising gradient, so that trains of wagons could be pushed up by a locomotive to the height necessary for the shipment of the ore to be effected by gravitation. Having regard to the large amount of material to be shipped, and to the advisability of being able to do this quickly, it was decided to adopt the latter plan, though it involved a more costly structure. The pier had been so designed that the wagons were run direct to the spouts, and required no handling after leaving the locomotive engine. To allow of the ore being shipped at all states of the tide, the shipping places were 32 ft. 6 in. above ordinary spring tides, and the pier was carried out into such a depth of water that the loading of a light vessel could be begun at the top of the tide, and be continued when the tide was at its lowest. Another advantage of this plan was the possibility of providing a lower deck for the ordinary traffic of the port, especially for that which would be brought to it when the Seville and Huelva Railway was completed.

The total length of the pier and of the approach from the station yard was 2,444 ft. The screw pile portion was 1,900 ft. long. This distance was made up of twenty-nine spans of 50 ft. each, and thirty groups of cast-iron screw piles and columns, eight in each group, placed 15 ft. apart from center to center. The pier-head, alongside which the ships were moored, was protected by the shipping deck wharf. This wharf was independent of the cast-iron piling, and was composed of creosoted redwood Memel fenders, supported by creosoted Memel piles, cross-bearers, transoms, and longitudinal walings. The face of the wharf opposite to each spout was close-sheeted with timbers, measuring 12 ins. by 6 ins., for a distance of 50 ft., the remaining portion being protected by vertical fenders placed at intervals of 3 ft. from center to center. The depth at low water spring tides at this wharf was 15 ft. There were three floors at different levels throughout the length of the pier, and upon these were laid seven lines of rails. These floors were carried upon wrought-iron lattice girders 4 ft. deep, and were supported by the screw piles and columns. The cast-iron hollow screw piles were 16 ins. in diameter, and the lowest length of the pile shaft was fitted with screw blades 5 ft. in diameter, and having a pitch of 6 ins. The principal difficulty was the want of solidity of the foundation, which proved to be worse than was at first anticipated. With two series of lines, one above the other, a greater load had to be borne than if the pier had simply to carry the work of the mines. It was found that the screw piles alone would not give sufficient area of base unless considerable expense was incurred in construction. It was therefore decided to provide additional bearing surface by the introduction of timber platforms fastened to the piles by cast iron disks, which clamped the respective piles below a collar cast specially upon the pile shaft, so as to rest upon the disk. In this way the load on the pier was transmitted through the columns, piles, and disks to the platforms, which rested on the bed of the river. The platforms at the shore end were weighted to 300 tons, and those in the deep-water section to 500 tons. When the loaded platforms ceased to sink, a diver was sent down to fix the disks forming the connection between the piles and the platforms, and the load was then removed.

There were four sets of shipping spouts, two on each side of the pier-head, constructed to meet the varying levels of the water and the different heights of vessels. Each set of spouts had four fixed divisions, the shoots being raised or lowered to any one of these divisions by side chains working in sheaves on a cross-bar spindle under the inner end. The shoot was adjusted to an inclination of 1¾ to 1, as a steeper angle caused a too rapid descent of the ore, while the ore did not readily clear itself from the spout if the angle was flatter. The quadrant and pinion, with hand-gear, fitted to the derrick frame, for moving the spout horizontally over the ship's hold, were most useful in trimming the ship during the operation of loading. The first-floor shipping deck was furnished with one 15-ton hand-power crane and one 3-ton traveling steam crane.

Mooring buoys were arranged round the pier-head, in the fairway of the river, so that vessels lay moored fore and aft in line with the set of the tide, at a distance of 300 ft. from the shipping deck wharf. Bollards and eye-bolt rings were fastened at intervals of 65 ft. to the wharf, to which the vessels were moored. Fifteen minutes sufficed to dispatch a loaded vessel from the wharf, and to place another from the tier in its berth ready to be loaded.

NEW YORK RAPID TRANSIT ELEVATED RAILWAYS.

The two rapid transit roads that are now approaching completion in New York City are remarkable specimens of constructive engineering. When fairly in operation, they will exhibit a new departure in railway transportation—an experiment, in fact, on a scale of such magnitude that its success or failure will multiply or put an end to all such undertakings in future. The material employed, the unique construction, the distance traversed, the service to be rendered, and the introduction of a new feature in city street architecture are all regarded with a peculiar interest by residents and strangers. The stable and solid road-bed upon mother earth, so indispensable to ordinary railways, is entirely dispensed with, and the tracks, with their weight of rolling stock and traffic, are elevated some twenty feet above the surface, the whole being supported by iron columns placed from 40 to 50 feet apart along the sides of the streets, and at some of the crossings as far as sixty feet apart. The structure is in fact a continuous bridge, which depends for its immunity from accident upon the strength of the weakest post or girder in it. The construction of the two lines differs materially, nor is it by any means uniform on either, but varies with different sections of the route. Trains are thrown from the track by broken rails, wheels or axles, quite often enough upon surface roads, where the track is on a level or nearly so with the earth alongside; but upon these elevated tracks, a fall of 20 feet or thereabout is inevitable if the iron framework breaks down, or if a car is thrown from the structure.

We have no doubt that these contingencies, and the peculiar risks of this method of transportation, have been duly considered, and every safeguard provided in the way of brakes, safety-straps and guard-rails, to prevent the possibility of a car being precipitated to the crowded street underneath, in case it should get off the rails, or a wheel or axle should break. Horse-cars and stages, with all their inconveniences, are liable to no "disasters" in the railway sense of the term; and even the old pioneer Greenwich street elevated track, with all the tinkering and reconstruction it has undergone, has not broken down or spilled any of its rolling stock into the street. This immunity from accident, gratifying as it is, is really a source of danger, as it is pretty sure to beget negligence, unless the management is such as to insure every day the same alertness and vigilance that were exercised on the day the road was opened to the public. The lines now being erected are of course a great improvement in point of construction over what was characterized a few years ago as the great engineering "fiasco" of Greenwich street, but the mechanical principle involved is substantially the same. There are the same slender supporting columns and long girders, supplemented on the Gilbert road with transverse girders strengthened with stays and rivets, and so connected as to

give the entire structure greater lateral stability, with less chance of the cars leaving their elevated perch, even if they should get off the rails.

Still the foundations, supports and fastenings, everything in fact that gives to these roads their distinctive name as distinguished from surface roads, are necessarily perishable from the wear and tear of a heavy, continuous and ever increasing traffic. No deterioration can take place without directly affecting the safety of those who ride on them. And aside from this, the structures, except where they are in the middle of wide avenues, will be constantly exposed to demolition wherever fires occur of sufficient magnitude to tumble down the walls of high buildings, against which the iron work would offer but a slight resistance. To meet such contingencies, a quantity of duplicate material of the different patterns used upon different sections of the lines will have to be kept in readiness for use in making repairs. It is more than likely that the long desired benefits of "rapid transit" will be realized at some slight sacrifice of safety. But even at the worst, the injuries sustained and lives lost will be but an infinitesimal percentage of the whole number of passengers transported. The first crash, like the first volley in battle, will occasion some trepidation, but the thing will soon get to be familiar and lose its terrors, like the general run of casualties.—*National Car-Builder.*

NEW RAILWAY ACROSS THE CONTINENT.

SINCE the accession of Mr. W. B. Strong to the vice-presidency and general management of the Atchison, Topeka and Santa Fe Railroad, due mention of which was made in the *Lumberman*, the affairs of that very important Western highway have undergone material change, and its present prospects for becoming of still greater importance as a great transcontinental route are of the brightest. It is a well-understood fact that another railway line to the Pacific is a national necessity. Everybody is familiar with Col. Tom Scott's Texas and Pacific scheme, and the desperate endeavors being made to obtain governmental aid for it. Without any such effort, and in a quiet, business-like way, arrangements have been perfected for the construction of a road across the mountains from the western terminus of the Atchison, Topeka and Santa Fe. A charter has been secured and preparations made for the immediate building of 111 miles of road from La Junta to Trinidad, and thence through Raton Pass to Clifton, on Red River, in New Mexico. The name of the road from this point on will be the New Mexico and Southern Pacific, of which Mr. Strong will be president. The charter confers the right to charge 10 cents per mile for passenger tariff and 15 cents per ton per mile for freight, until the company earns 60 per cent. upon its investment, after which time the Legislature will have the right to fix the rates.

It is expected that the new line will be completed as far as Trinidad by December 1 of the present year. After reaching Clinton it will be extended to Las Vegas, *via* Fort Union, as fast as circumstances will permit. The money for 225 miles is now in hand, and the known energy of the manager is a guarantee that the distance will be made in the shortest possible time. The objective point is Fort Yuma, on the Southern Pacific. The distance to be built from the Atchison, Topeka and Santa Fe, however, is only 900 miles, while from the present end of the Texas and Pacific it is over 1,300 miles, a great point of vantage for Mr. Strong's road.

The owners of the Atchison, Topeka and Santa Fe are New England capitalists, with ample means to carry their project to successful completion without any subsidy from Congress, or any other aid than the privileges commonly accorded such gigantic enterprises, for this one is nothing less than gigantic in the light of the present condition of the commercial and transportation interests. Of the present completed portion of this road it can be said with truth that it is one of the most important in the West. It traverses the entire length of the great State of Kansas—the present Mecca of western-bound emigrants—through some of the richest agricultural sections of this continent, which must sooner or later be inhabited by a people who will build up one of the greatest States in the Union through the aid of this magnificent railway enterprise. Although our people are much given, of late, to grumbling at railway "monopolies" and the like, they cannot deny that the populating of new countries and development of natural wealth have always depended upon and been induced by just such bold investments of capital as this second attempt to span the continent with the iron rails of progress. The famous San Juan mining country is in reach of and has been effectually brought to notice by the Atchison, Topeka and Santa Fe Railroad. The wealth of its mineral resources is reputedly great, while the riches hidden within the alluvial soil along its pathway to the mountains are undeniably so.

Kansas is of special importance just now to lumbermen, as any region must be to which emigration is so great. The west-bound trains for weeks have been crowded with people seeking homes upon the great plains. The demand for building material has, in consequence, been enhanced and will continue large, without doubt, if present crop prospects are but half realized. A great strife has been waged among our Chicago lumbermen for this new trade, and Kansas shipments for a couple of months have been very large. Each new extension of a line of railway in this new country creates a demand for lumber, and every new town must have its lumber yard just the same as it must have its store for the sale of general merchandise. The new farms must be fenced, and houses and barns must be erected for the accommodation of the people and their primitive possessions. Those who have already begun to raise the question as to where the future demand for lumber is to come from are referred for a solution of the problem to the broad plains of the great West, crossed and recrossed with lines of railway that will yet rear up another nation, as great as our present one, on what is now waste room. Far more sensible would be the query, Where is the supply to come from to meet the demand which prospective development seems certain to create?—*N. W. Lumberman.*

BEAMS.

Theory of Strength.—Certain relations exist between the load and the resistance of a beam. The load exerts a force equal to the product of half the load multiplied by half the length of beam. The power of the beam's resistance to this load is measured by the cross section, viz.—the product of the area of cross-section of a beam multiplied by its depth and by the strength of the unit of material is equal to the power of resistance. At the moment of rupture these two forces are equal—that is to say, the weight multiplied into the leverage at which it acts equals the resistance at cross section, or the breadth multiplied by square of depth and by the constant of strength. All rules for the strength and stiffness of beams are founded upon this relation. We shall confine ourselves chiefly to beams of timber.

"J. A." writes: "Bending and cross breaking are produced by a transverse load. The simplest case of a transverse load is when three parallel forces applied to a beam balance each other. In order that they may balance each other, the middle force must act in the contrary direction to the two endmost forces, and each of the three forces must be proportional to the distance between the other two. For example, the middle force may be a weight resting on the beam and the endmost forces, the upward pressure exerted by two props that support it, or the endmost forces may be weights resting on a beam, and the middle force the upward pressure exerted by a prop. The external forces that act upon a beam having been determined, the straining actions which they exert at a given cross-section of the beam are found as follows:—Consider all the external forces which act on one only of the two parts into which the cross-section divides the beam, and take their resultant. This will be the shearing action at that cross-section, and the particles at the cross-section ought to be able to exert an equal and opposite shearing stress. Then take the resultant moment of the same external forces—that is, multiply their resultant by its leverage or perpendicular distance from the given cross-section. This will be the bending moment exerted at the given cross-section, and the particles at that cross-section ought to be able to exert an equal and opposite moment of resistance. The moment of resistance is produced in the following manner:—When the beam bends one side of it becomes compressed and the other stretched. In general, the side toward which the middle external force acts is stretched, and the other side compressed. For example, when a beam is loaded in the middle and supported at the ends, the lower side is stretched and the upper compressed; and when a beam is supported in the middle and loaded at the ends, the upper side is stretched and the lower compressed. In practice, the strength of a beam against the shearing action of the load is, in general, more than sufficient; so that the bending moment and the moment of resistance are chiefly to be considered, and, in particular, the bending moment and moment of resistance at that cross-section at which the bending moment is greatest. The cross-section is situated as follows:—In a beam supported at both ends, and loaded at any intermediate point, or supported at any intermediate point, and loaded at the ends, the intermediate point; in a beam supported at both ends, with a uniformly distributed load, the middle of the beam; and in a beam supported at the ends and loaded in any manner, the point which divides the load into two parts, respectively equal to the supporting pressures. The magnitude of the load is most conveniently expressed in pounds, and the leverage in inches; so that the bending moment is expressed in inch-pounds. In the following formulæ W denotes the total load in pounds; c, in beams fixed at one end and free at the other, the length of the free part in inches; c, in beams either loaded or supported at both ends, the half-span, between the extreme points of load or support and the middle, in inches; M, the bending moment in inch-pounds.

For Beams.

Fixed at one end and loaded at the other. $M = cW$

Fixed at one end and uniformly loaded.. $M = \dfrac{cW}{2}$

Supported at both ends, and loaded at an intermediate point, whose distance from the middle of the beam is x........ .. .. $M = \dfrac{(c^2 - x^2)W}{2c}$

Supported at both ends and loaded in the middle.................................. $M = \dfrac{cW}{2}$

Supported at both ends and uniformly loaded.................................. $M = \dfrac{cW}{4}$

If W be the intended breaking load of the beam, found by multiplying the working load by a proper factor of safety, M will be the moment of rupture, to which the moment of resistance to rupture at the place where the tendency to break is greatest must be made equal. The moment of resistance is given by the formula: $M = nflh^2$, in which l denotes the extreme breadth of the piece in inches; h, its extreme depth in inches; f, a factor depending on the materials called the modulus of rupture in pounds on the square inch; n, a factor depending on the figure of the cross-section. M having been computed from the breaking load and its leverage, and f and n being known, the transverse dimensions of the beam are to be such that $lh^2 = \dfrac{M}{nf}$. It is obvious that the breadth and depth may be varied, and still give the product lh^2 the same value, but there are limits to the variation founded on considerations of stiffness and stability. With regard to cast-iron beams: To find the ultimate strength of a rectangular beam of cast iron, supported at both ends, multiply the breadth into the square of the depth, and that again by the constant 2580, and the last product divided by the length in feet will be the quotient = the weight in pounds avoirdupois nearly. In the case of any beam being fixed at one end and loaded at the other it is known that it will bear only ¼ of the weight it would bear in the middle when supported at both ends.

Floor Beams.—In estimating the load upon a floor beam we have to calculate the load upon so much of the floor as extends half way on each side to the adjacent beams, or we measure the floor the length of beam by the distance apart between the centers of two beams. If the load in pounds upon each superficial foot of floor is known, we multiply it by the length of beam and by the distance apart of the beams, which will give the load upon the floor-beam required. The greatest load to be provided for in the floors of dwellings or assembly rooms has been calculated at 70 lbs. per superficial foot, and floor-beams should be calculated to sustain this load—*i. e.*, to break with not less than three or four times this. Allowing 90 lbs. per foot, including beam, the general formula for strength of beam is 180 $cl^2 = Bbd^2$, in which B represents the weight in pounds required to break a unit of the material an inch square and one foot long, b and d, the breadth and depth of beam in inches, c the distance in feet of beam apart, and l length of beam. Tredgold's rules for the stiffness of beams are the following:—1. To find scantling of a piece of timber to sustain a given weight when supported at ends, the breadth being given—Rule: Multiply the square of length in feet by the weight in pounds, and this product by value of a. Divide product by breadth in inches, and the cube root of quotient will be depth in inches. Example: A beam of Norway fir is required for a 24-ft. bearing to support 900 lbs., breadth to be 6 in. Here $\dfrac{24 \times 24 \times 900 \times \cdot 00927}{6} = 827$, and the cube root of $827 = 9\cdot 38$ in., depth required. 2. When depth is given—*Rule:* Multiply the square of length in feet by weight in pounds, and multiply this product by value of a. Divide last product by cube of depth in inches, and quotient will be the required breadth in inches. The stiffest proportion for a beam is when breadth is to depth as 0 6 is to 1.—G. H., *in Building News.*

PITCHES FOR SCREWS WITH ANGULAR THREADS.

No. of screw threads per inch.	Old sizes.	New standards of size. Decimals of an inch.
40	⅛	·125
32		·150
24		·175
24		·200
24		·225
20	¼	·250
20		·275
18		·300
18		·325
18		·350
16	⅜	·375
16		·400
14		·425
14		·450
14		·475
12	½	·500
12		·525
12		·550
12		·575
12		·600
11	⅝	·625

WHITWORTH'S STANDARD PITCH OF THREADS.

⅛ has 30 threads to the inch.
3/16 has 25 " "
¼ has 20 " "
5/16 has 18 " "
⅜ has 16 " "
7/16 has 14 " "
½ has 12 " "
⅝ has 10 " "

THE PIG IRON PRODUCTION OF THE UNITED STATES.

STATISTICS have just been published by the American Iron and Steel Association from which it appears that the grand total for 1877 was 2,314,585 tons of two thousand pounds, against 2,093,236 tons in 1876, a gain of 221,349 tons. Twenty-two States made pig iron in 1877. As compared with other years immediately before and since the panic, the production of 1877 shows a decided reaction from extreme depression, but still falls far short of the country's best achievements. The figures are as follows: 1872, 2,854,558 net tons; 1873, 2,868,278 tons; 1874, 2,689,413 tons; 1875, 2,266,581 tons; 1876, 2,093,236 tons; 1877, 2,314,585 tons. The production in 1877 was about 50,000 tons greater than in 1875. The year 1876, the Centennial year, was the year of greatest depression, and 1873 was the year of greatest production. Of the total production of pig iron in 1877, 1,061,945 net tons were bituminous coal and coke, 934,797 tons were anthracite, and 317,843 tons were charcoal. In 1873, the year of greatest production, the proportions were as follows: Anthracite, 1,312,754 net tons; bituminous coal and coke, 977,904 tons; charcoal, 577,620 tons. It will be seen that, while the production of anthracite and charcoal pig iron has largely fallen off, that of bituminous coal and coke pig iron has very materially increased. The whole number of furnaces in the United States which were completed and either in blast or ready to be put in blast at the close of 1877 was 716, against 712 at the close of 1876. Of the furnaces completed at the close of 1876, 236, or less than one-third, were then in blast, and 476 were out of blast. At the close of 1877 there were 270 in blast and 446 out of blast, showing an increase in that year as compared with 1876 of thirty-four active furnaces. Some of the revelations made concerning furnaces in and out of blast are exceedingly discouraging to Americans. Notwithstanding the aggregate increase of active furnaces at the close of 1877, of twenty-four furnaces in Maryland, only six were then in blast; of thirty-three in Virginia, only five were in blast; of seven in North Carolina, every one was silent; of eleven in Georgia, only two were running; of thirteen in Alabama, seven were in blast; of twelve in West Virginia, only two were in blast; of twenty-two in Kentucky, seven were in blast; of twenty-two in Tennessee, six were in blast; of eight in Indiana, only one was in blast; of twelve in Illinois, only two were in blast; of thirty-two in Michigan, only nine were in blast; of fifteen in Wisconsin, only four were in blast; of eighteen in Missouri, only two were in blast; of 278 furnaces in Pennsylvania, 147 were out of blast. The consumption of pig iron in 1877 was apparently greatly in excess of the consumption in 1876. The production was greater and stocks in the hands of makers were reduced. At the close of 1876 makers' stocks amounted to 686,798 net tons, and at the close of 1877 this quantity had been reduced to 642,351 tons, a difference of 44,447 tons. The imports of pig iron in 1877 amounted to 66,871 net tons, and our exports to 7,687 tons, showing a difference in favor of importations of 59,184 tons. If we add the production of 2,314,585 net tons in 1877 to the reduction of 44,447 tons in stocks and the net importation of 59,184 tons, we have an approximate consumption last year of 2,418,216 tons, against 2,172,508 tons in 1876. This increased consumption, which was due to the increasing demand for iron and to the ruinously low prices which prevailed throughout the year, must have been mainly confined to the car-wheel works, machine shops, pipe works, and other foundries, as we made fewer rails in 1877 than in 1876, and but little more rolled iron in other forms. The concluding sentences of the report from which we have taken the preceding figures are eminently suggestive: "The fact remains, notwithstanding the increased consumption of 1877, that prices of pig iron were alike ruinous to the capital invested in its manufacture and to the labor which produced it. Neither was adequately rewarded, and in many instances the sheriff's writ attested that capital was not rewarded at all. Prices of pig iron in 1877 were lower than ever before known. And the situation for the pig iron makers and their workmen is no better on this first day of April, 1878, than it was on the last day of December, 1877." Why Brother Jonathan should be so enamored of a trade which is neither necessary to his existence nor able to add to his comforts, is a problem which we confess we are unable to solve.—*Engineer.*

VARIOUS BUILDING MATERIALS.

Limestones derive their name from the fact of their being chiefly composed of lime (calcic-oxide) in combination with carbonic acid, which latter is given off as a gas, with violent effervescence, when a dilute acid is applied to a limestone that has been reduced to powder; and this forms an excellent means of distinguishing it from any other kind of stone. In almost all the various geological series we find beds of limestone, some of which are good for the use of the mason, while a very large proportion are only fit for burning into lime or for purposes of iron smelting. Limestones may generally be distinguished from sandstones by the absence of any lamination in their structure, so that after a stone has been removed from its quarry it is often difficult to determine which is its natural bed.

One of the oldest of this class of rocks in geological series is the *mountain limestone*, of the carboniferous formation, which is very hard and unfit for masonry, being chiefly used for converting into lime; it contains about 95 per cent. of carbonate of lime, with from 1 to 2 per cent. carbonate of magnesia, and about the same proportion of silica, together with a little iron and alumina. The lime which it yields is one that slacks slowly, on which account it is termed a *poor* lime. Limestones of a similar kind are also found in the higher geological series, as the *rags* of the lower chalk formation, which are sometimes used for rough walling, but more commonly for producing lime to be used in making mortar. A *poor lime* requires only a moderate admixture of sand to make mortar, as 2 or 3 parts of sand to 1 of lime. Other limestones which are too soft to resist weather, and are otherwise unfit for masonry, produce, when burnt in a kiln, a *rich* or *fat* lime, which slacks rapidly when mixed with water, and requires 3 or 4 parts of sand to 1 of lime. The mortar made from a *rich* lime is not generally so strong or durable as that from a *poor* lime.

Those limestones which contain a considerable proportion of silica, iron, and alumina, produce, when burnt, a lime that, when mixed with a moderate proportion of sand, will harden or *set* under water; such limes are termed *hydraulic*, being of great value for buildings which have to stand in water, as the piers of bridges, quays, docks, &c. They are chiefly obtained from the stratum called by geologists the "blue-lias," which underlies the oolitic series.

The chemical process which takes place when lime is employed to make mortar appears to be somewhat as follows: The carbonate of lime, on being subjected to great heat in a close kiln, parts with its carbonic acid and water, and is then reduced to the form of oxide of calcium, or *quick* lime. This material has a great avidity for water, which it will absorb from the atmosphere if left exposed, and when water is poured over it a chemical combination ensues, with a great development of heat, a hydrate of lime being then formed, and it is then said to be *slacked*. By mixing a large proportion of sand or siliceous grains with the lime it acts as a cement to unite the particles of sand into a solid mass, and by exposure to the air it also gradually absorbs the carbonic acid therefrom, which it previously evolved in the kiln, and thus returns to its pristine form of limestone. The sand used for mortar should be *sharp*—that is, as free as possible from earthy or argillaceous matters, which have the effect of weakening it. For limestone suited to the requirements of the mason we are most largely indebted to the oolitic formation, the stones of which series of rocks are distinguished by the resemblance they present to the roe of a fish, and are hence termed *roestones*, being composed of small round calcareous particles, very often minute shells, cemented together by carbonate of lime. The oolitic series are found extending over a large portion of the southern, western, eastern, and midland counties of England in two great divisions, the lower one being the Bath oolite, and the upper the Portland oolite. The former of these is the most extensive, being quarried in the counties of Somerset, Wilts, Oxford, Rutland, Northampton, Cambridge, and Lincoln; these stones are generally devoid of silica, and capable of being cut with a tooth-saw without the aid of sand or water, and can be worked with very little labor when fresh out of the quarry, but harden upon exposure to the air. The proportion of carbonate of lime in their chemical composition varies from 92 to 95 per cent., and of carbonate of magnesia from 1 to 3 per cent., iron and alumina being about 1 per cent. They absorb water to a considerable degree, but some kinds much more than others; thus, the Bath stone will take up one-third its bulk of water; that of Ketton, in Rutlandshire, one-fourth; while the stone obtained from Ancaster, in Lincolnshire, absorbs only one-sixth of its bulk of water when immersed therein. The non-absorption of water is, in fact, proportionate to their density, Bath stone having a specific gravity of 1·84, Ketton of 2·05, and Ancaster 2·18. All these stones are readily decomposed by dilute acids, and but few of them will resist, for any great length of time, the action of the weather—that of Ancaster being the most durable in buildings away from the effects of coal-smoke, being a hard, fine-grained, and compact stone, having a crushing strength of about 1,800 lbs. per square inch. The stones from the neighborhood of Bath are very soft, their surface being easily brushed off by the hand; the Boxhill stone is the most durable, as well as the hardest and strongest of these, some kinds having a crushing strength of 1,500 lbs. on the square inch.

Portland Cement.—The stone found in the highest or Portland series of the oolites is one of the most valuable for masonry which this country possesses, this name being given to it from the fact of its being chiefly quarried in the island of Portland, in Dorsetshire, although the same series is found in Wilts and other counties. It is much harder to work than the stones above mentioned, as it always contains a proportion of silica, varying in quantity from 1 to 10 per cent. of its weight. In the stone of Portland island the proportion of silica is not generally more than 1¼ per cent., with about the same weight of carbonate of magnesia, combined with 95 per cent. of carbonate of lime, and a little iron and alumina. There is much difference in the hardness, density, and absorbent power of Portland, of which the specific gravity varies from 2·1 to 2·35, the best and most durable having a specific gravity of 2·2, and being capable of absorbing about one-fifth of its bulk of water. The hardest and best weather stones are generally got from the upper beds, the quality degenerating as we descend, which is the case with all the oolites; those which stand weather best have a hard crystalline cement to hold the particles together. The crushing strength varies from 3,000 up to 3,700 lbs. on the square inch. Portland stone which is very white is not so durable as that of a darker tint, known among masons as "brown Portland," and which is generally specified for work that is much exposed to weather. There is a trace of bitumen found in the composition of all stones of the oolite series.

Chilmark Stone.—The stone of Chilmark, in Wilts, belongs to the same series, but contains a much larger proportion of silica than is found in that of Portland island; in some kinds there is as much as 10 per cent. of silica, with 79 per cent. carbonate of lime, 4 per cent. carbonate of magnesia, and 2 per cent. of iron and alumina. The hardest qualities of Chilmark stone absorb only from one-tenth to one-twentieth of their bulk of water, and possess considerable density, the specific gravity being from 2·37 to 2·48—the heavier stones being less absorbent than the lighter. Those kinds which contain a large proportion of silica are termed "siliceous limestones," and are very durable for outside work exposed either to weather or smoky atmosphere. In point of strength, the Chilmark stone is equal to the best quality obtained from Portland island.

Caen Stone.—The stone of Caen, in Normandy, which is largely imported into this country, is also a "siliceous limestone," since it contains as much as 12 per cent. of silica, combined with 85 per cent. carbonate of lime, with 2½ per cent. iron and alumina. In all other respects, however, it is very different to the Chilmark stone, being very soft and easily worked, and possessing a much lower degree of density. Its specific gravity varies from 1·86 to 2·06, and it absorbs water very readily; but being of fine grain and even texture, as well as possessing a warm tint, it is valuable for internal decorative work, and especially suited for carving, but its durability cannot be relied upon when it is used for external masonry.

Marbles, from their chemical composition, must be considered as limestones which have become crystallized and hardened by the action of heat, so as to be capable of receiving a high degree of polish. The action of heat on ordinary limestone is seen wherever such strata have come in close proximity to granite, the heat from which, when in a molten state, having converted the stone into crystalline marble. We may, therefore, expect to find marble among all the great limestone formations—the most valuable, however, being those which belong to the oldest series of rocks, as the Devonian and Carboniferous. In the British isles all the marbles which are found are variously colored from being mixed with the oxides of metals, iron giving the red and brown tints, copper the green, and manganese the black. Marbles having all these varieties of color are found in North and South Devon, Derbyshire, and various parts of Ireland. In other countries we obtain pure white statuary marble, the finest of which is found in the Apennines of Italy; when this is reduced to powder, and mixed with dilute hydrochloric acid, the carbonic acid gas is given off with violent effervescence, and nearly the whole of the solid matter is dissolved. If marble is exposed to the action of great heat in a close vessel, pure caustic lime is obtained.

Alabaster or *Gypsum* may also be classed among limestones, since it is a hydrous *sulphate of lime*, the pure white alabaster used for statuettes containing 32½ per cent. of lime, 46½ of sulphuric acid, and 21 of water. The veined and colored varieties found in some parts of this country contain oxide of iron in greater or less proportion. Gypsum is slightly soluble in rain water, and unsuited for external work, but is much valued for internal decorations. When heated it parts with its water and falls into a fine powder, known as "plaster of Paris," from its being obtained in large quantities from the beds of gypsum found in the neighborhood of Paris. When this powder is brought in contact with water it absorbs it eagerly and returns to its original hardness.

Magnesian-limestones are those in which a large proportion of the carbonates of magnesia and lime are found in combination; they abound in the geological series which overlies the coal-measures, and are often termed "dolomites," after the French geologist Dolomieu. In England these stones exist chiefly in the counties of Nottingham, Derby, and York; and on the Continent, in the Pyrenees, Saxony, and other places. The proportion of carbonate of magnesia varies from 25 to 42 per cent., while that of lime is from 50 to 68 per cent., the most durable being generally those in which the lime and magnesia are nearly equal in proportion. Silica is found in most of them in moderate quantity, sometimes as much as 3½ per cent., with a little iron and alumina. It is only the hard, heavy, and crystalline rocks of this class that can be relied upon for durability when exposed to weather, the soft stones being very liable to disintegration. Their specific gravity varies from 2·13 to 2·32, and the absorbent power from one-fourth to one-sixth of their bulk, according to their density. These stones can readily be distinguished from other limestones by their very much feebler effervescence on the application of dilute hydrochloric acid. The crushing strength of the hardest is as much as 8,300 lbs. to the square inch, while the softer stones will yield to half that load. The red and white Mansfield stone has been already noticed under the head of "Sandstones," since they contain from 50 to 51½ per cent. of silica, and have a laminated appearance. They may, however, be considered as *siliceous dolomites*, since the proportion of carbonate of magnesia is from 16 to 18 per cent., with 26½ per cent. of lime; they also belong geologically to the magnesian-limestone series.

Slates are stones which possess a highly laminated character, and are therefore capable of being split up into very thin plates, chiefly for the purpose of covering the roofs of buildings. They may be divided into two distinct classes—*Clayslates* and *Tilestones;* the former of these are, however, far more largely used for roofing purposes than the latter. *Clayslates* are metamorphic rocks found among the oldest of the geological strata, their original beds having been completely obliterated and overridden by a peculiar kind of lamination called "cleavage," by means of which they can be split up into plates of any degree of thinness. They are found largely in North Wales, Cornwall, Westmoreland, the west of Scotland, and at Valentia on the west of Ireland. Welsh slate contains about 60 per cent. of silica, 20 per cent. of alumina, 8 of the protoxide of iron, with small proportions of lime, magnesia, potash, and soda. The geological formations in which clay-slates are found are the Cambrian, Silurian, and Devonian. The green and purple Penrhyn slates of North Wales belong to the *Cambrian* series; the dark slates of Portmadoc, with those of Inverness and other parts of Scotland, and the bluish-gray slates of Tipperary, in Ireland, are referred to the *Lower Silurian* series; the green and pale blue of Westmoreland to the *Upper Silurian* rocks; and those of Cornwall, Devonshire, and Valentia to the *Devonian* series. They are found in every variety of tint, but some are much more absorbent than others, the hardest and finest grained being the least absorbent, and the best suited for roofing purposes. They are the densest of the stratified sedementary rocks, having a weight of 170 lbs. to 180 lbs. per cubic foot, and the average crushing strength is 20,000 lbs. per square inch, although some kinds will resist nearly double that load; they also possess greater transverse strength than any other kind of stone.

Tilestones are simply thin-bedded sandstones, which, after exposure edgeways to a winter's frost, will split up readily along their *natural* bed into "flags" thin enough to serve for roofing purposes. The chief source of these is the carboniferous sandstone, from which paving stones are obtained, but their use as "slates" is confined to the districts in which they are quarried. The "Stonesfield slate" of the lower oolitic series also produces a similar kind of roofing material. A house whose roof is covered with *tilestones* has an advantage over one in which *clayslate* is used in being warmer in winter and cooler in summer, from the greater thickness of the roofing material, and its being a non-conductor of heat; they are, however, being rapidly superseded by the lighter and more adaptable material.—*Building News.*

PHYSICAL SOCIETY, LONDON.

April 13, 1878.

Prof. R. B. CLIFTON, Vice-President, in the chair.

Telegraph Experiments.—The Secretary read a paper by Messrs. J. Nixon and A. W. Heaviside, describing their experiments on the mechanical transmission of speech through wires or other substances, to which Mr. Preece had referred at a previous meeting of the Society. After describing a number of experiments, in which metallic disks soldered on to the ends of the conducting-wires were employed, they went on to enumerate the more successful experiments, in which wooden disks were mainly employed. The first actual transmission of speech was effected by placing the belly of a violin against the receiving end of the wire, when every syllable spoken was distinctly audible. Very good results were obtained by employing mouth and ear-pieces formed as in a telephone, the disk being replaced by thin wooden disks 6 inches in diameter, and a No. 4 wire was found to be most satisfactory. On suspending a length of this wire in such a manner that it had no rigid attachments, it was ascertained that 120 yards is the limit through which a conversation can be carried on.

Photography of the Red.—Captain Abney, F.R.S., described the method he adopted for photographing the least refrangible end of the spectrum. He pointed out that it is impossible with the ordinary sensitive salts employed in the usual way to photograph further than the Fraünhofer line E, though by a preliminary exposure to light of a daguerreotype plate Draper was able to photograph beyond the extreme limit of visibility in the red end of the spectrum. This method, however, gave what is known as a reversed picture, the lights and shades being transposed, besides requiring a lengthened exposure. It enabled Becquerel to photograph the spectrum in its natural colors, and, later, St. Victor obtained colored images of colored cloths. The object of Captain Abney had been to obtain unreversed pictures of this portion of the spectrum; in other words, to obtain a compound that would be similarly sensitive to the red and the blue components of white light. Such a compound he had at last obtained by what he termed *weighting* silver bromide with resin, and now he obtains it by causing the molecules of silver bromide to weight themselves. He showed an ordinary bromide of silver plate, and the color of the transmitted light was of a ruddy tint, showing absorption of the blue rays. Another film was shown, containing weighted bromide of silver, which transmitted blue light and absorbed the red. Photographic plates prepared with the latter compound he showed were sensitive to the red and ultra-red waves of light, and he threw on the screen photographs of the spectrum from the line C to a wave-length of 10,000, the ultra-red showing remarkable groupings of lines. He further showed that by friction the blue film was changed to the red, and in that state was not sensitive to the lower part of the spectrum. These photographs were taken by means of a diffraction grating, and Captain Abney demonstrated Fraünhofer's method of separating the various orders of spectra produced by it. He then explained that recently he had elucidated the reason of the reversal of Draper's pictures by the least refrangible end of the spectrum. He finds that it is accelerated by exposing the plates in weak oxidizing solutions, such as those of hydroxyl, bichromate of potash, permanganate of potash, and nitric acid, or exposure to ozone. The red rays, in other words, seemed to oxidize the photographic image, and to render it incapable of development.

Crystals.—Mr. H. Bauerman then exhibited some paper models, illustrative of the disposition of the planes of symmetry in crystals. These included octants of the sphere with inclosed cube and octahedron faces pointed into their corresponding hexakis octahedral faces, a cubic skeleton built up from nine planes of symmetry, with a removable outer shell, and a system of axial planes of an unsymmetrical mineral, inclosing a solid nucleus contained between three parallel pairs of planes. They were constructed for the purpose of showing popularly the difference between planes of symmetry and other diametral planes by laying upon them a small mirror or plate of mica, when, in the first case, the inclosed nucleus gave a symmetrical image corresponding in position to the plane immediately behind the mirror, but in the second a broken image is produced.

Transpiration of Gases.—Dr. Guthrie exhibited the arrangement of apparatus he had employed, in conjunction with his brother, to ascertain the effect of heat on the transpiration of gases. The main difficulty connected with the research was the securing of an absolutely constant pressure on the air operated upon. This was secured by inserting into the neck of the vessel which served as an air-chamber a tube turned up at its inner end and terminating externally by a small funnel; as the tube was kept constantly full of water, the funnel overflowing, a pressure represented by the difference between the heights of these levels was maintained. After passing through a series of drying tubes the air traversed the (U-shaped) capillary tube in a beaker containing water of known temperature, and was finally received in an inverted tube contained in an overflowing dish of water. Among other results it was found that the resistance of a tube is the same as that of its several portions, and if t be the time occupied, T the absolute temperature, P_1, P_2 the pressures, and a and β constants, they find that—

$$t = aT\left(T + \frac{\beta}{P_1 - P_2}\right).$$

NEW BRICK KILN.

A NEW brick kiln was recently tried at Normanton, England, the advantages claimed for which are economy in fuel and labor. The kiln is 108 ft. long and 8 ft. broad. The raw bricks are set direct from the making machine upon iron wagons, which carry them through the entire length of the new kiln and bring them out at the exit end baked, which saves much of the usual handling. The fires are

placed in the middle of the kiln, at each side, and the draught of hot air travels toward a flue or chimney at the entrance end. By this means the bricks are gradually baked before reaching the fires, and, after passing the intense heat of the central section, they have time to cool before being drawn out at the receiving end, where the burnt bricks can at once be thrown into carts and railway wagons or stacked. The barrows, of which nine are in the kiln at one time, are coupled together, and the action of drawing one out advances each of the succeeding eight a stage, while at the same time pulling in a newly loaded one at the other end. Each wagon holds about 5,000 bricks, making 45,000 in the kiln at once, or a total weight of about 300 tons. The wagons are made so as exactly to fit the breadth of the kiln, and, excepting the usual spaces left for the equal penetration of the heat through the entire mass, the bricks are piled upon each wagon to a height of 7 ft., thus filling up the whole space of the arch through which they pass. The iron of which the lower parts of the wagons are composed is preserved from injury through the heat, not only by the fires being on a higher level, but by a superposed layer of fire-bricks, and by a current of cool fresh air being secured under the wagons. By means of Mr. Foster's appliances, which may be further improved, a load of 5,000 finished bricks can be drawn out in five minutes; but a period of four or six hours in the kiln is required before the bricks are sufficiently burned and then cooled enough to be taken out.

M. GIFFARD'S GREAT BALLOON AT THE PARIS EXPOSITION.

THE construction of the monster balloon designed by M. Henri Giffard, the well-known inventor of the Giffard injector, the project of which we have already announced, is rapidly being carried forward in the plot of ground especially set apart for the accommodation of the apparatus, etc., near the ruined Palace of the Tuileries in Paris. The size of this enormous air ship will far exceed that of any hitherto made. It will be 115·2 feet in diameter and 882,500 cubic feet in volume. When anchored, its summit will be 176 feet above the ground, or 32 feet higher than the top of the Arc de Triomphe. The cable which holds it will be 1,980 feet long, weighing 6,600 pounds, and two 300 horse-power engines will operate the winding drums. Fifty passengers will be taken up at once in the car.

Not only is this Great Eastern of balloons remarkable for its gigantic size, but for the many ingenious devices which have been invented and applied to it by M. Giffard. The net, for example, represented of full size, seen from above and below in Fig. 1, is formed of rope ·42 inch in diameter, and is not knotted, as is usually the case. Instead one part of the cord passes through the other part at the intersection. As this netting involves some 80,000 feet of rope, especial arrangements have been necessary for its manufacture. Three circular balconies are constructed in the middle of a large rope factory at Vincennes, and upon these and on the ground the one hundred and ten workmen interlace the cords. As fast as the crossing is effected the net is hoisted, and workmen above put on the seizings of tarred twine. Above this again are pieces of leather securely lashed so as to prevent any chafing of the fabric of the balloon. There are no less than 52,000 meshes, and the weight of the net is 6,600 pounds. The cost of the cordage alone connected with the balloon exceeds $10,000.

The cable is made slightly tapering, being about three inches in diameter at its lower extremity, and a little more than half this at the end attached to the balloon. Its breaking strain varies according to its section from 55,000 to 88,000 pounds, which is at least double the stress to which it will be submitted while in use.

Ordinary balloons are constructed of silk covered with a varnish made of linseed oil boiled down, but this material M. Giffard considers unsuited for so large a balloon as his, and he has therefore devised the compound fabric represented in Fig. 2. This consists, first, of a layer of muslin, *c*; second, a layer of rubber, *b*; third, a tissue of linen cambric, *a*, of special construction, equally strong in warp and weft; fourth, a second layer of natural rubber, *b'*; fifth, a second layer of linen cambric, *a'*, like the first; sixth, a layer of vulcanized rubber, *b''*; seventh, an outer cover of muslin, *c'*. The muslin is covered with a varnish of boiled linseed oil containing a certain quantity of rubber dissolved in turpentine. The whole is finally covered with zinc white paint, the object being to render the surface as little absorbent of the sun's rays as possible, so as to prevent the heating and undue expansion of the gas. More than 4,300 yards of fabric, 42 inches in width, will be used in making the huge bag. Each square foot weighs about ·2 of a pound, and the cost is nearly thirty cents per square foot. The total surface will be about 41,000 square feet.

The seams are made by the sewing machine, and are double, as shown in Fig. 3. They are covered with two bands, one inside formed of muslin covered with rubber, and the other outside. The latter consists of a layer of vulcanized rubber between two strips of muslin. These bands alone weigh 1,100 pounds, and their fabrication requires 18,000 square feet of material. We are indebted to *La Nature* and to *L'Illustration* for our engravings.

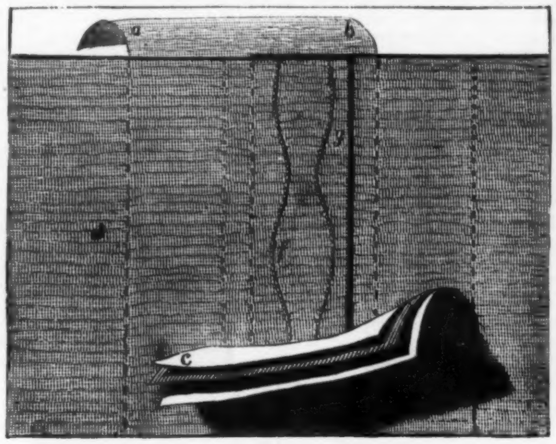
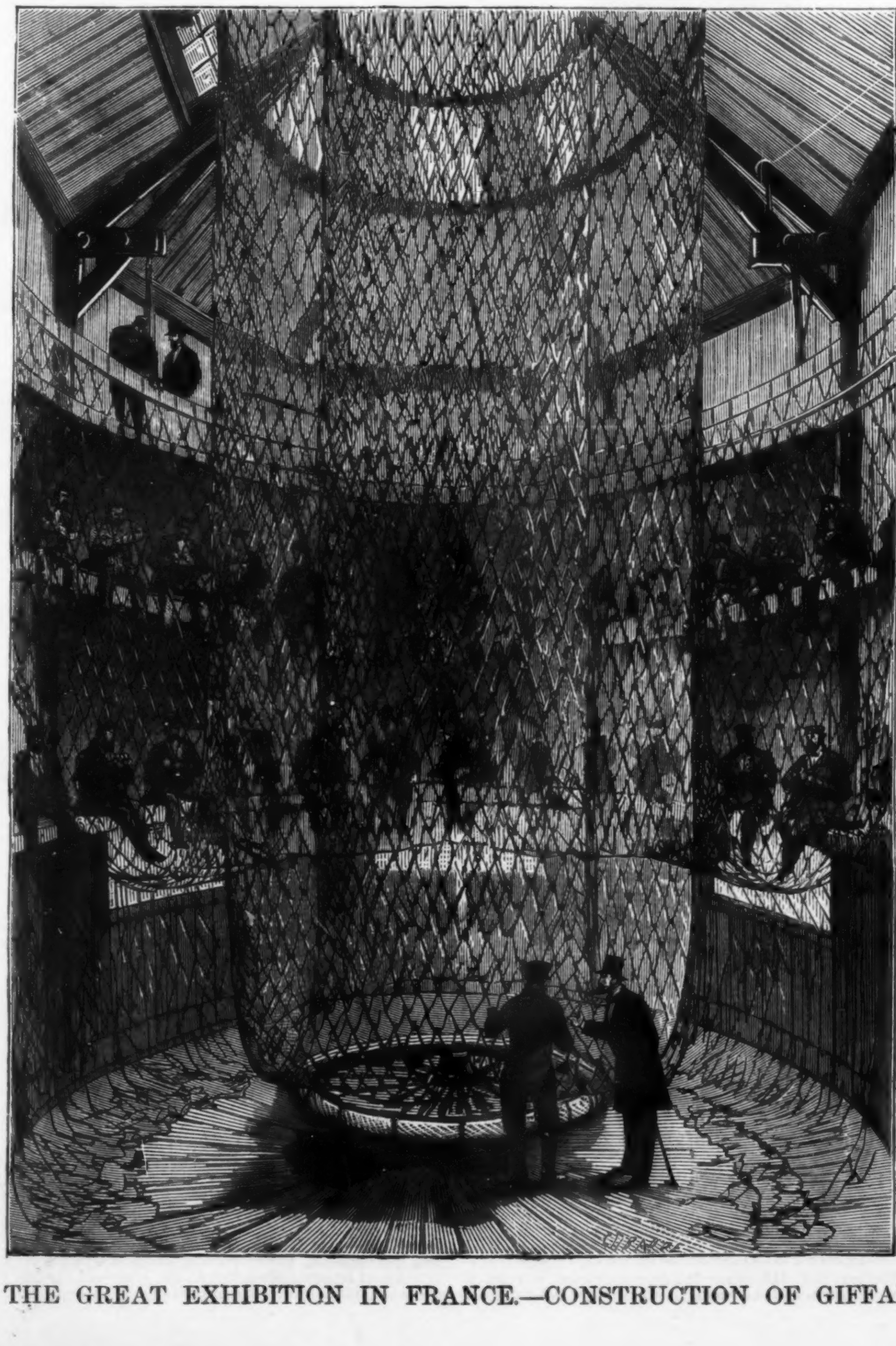


Fig. 3.



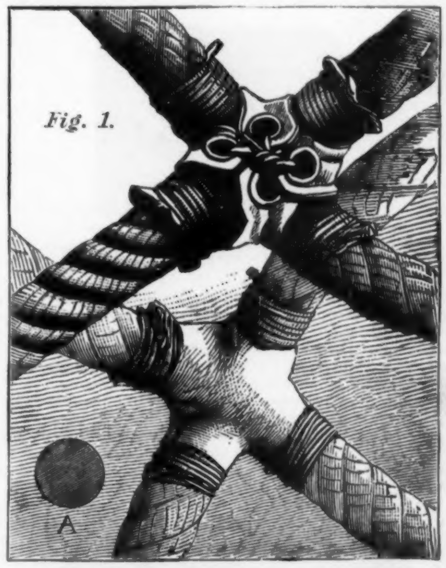


Fig. 1.

Fig. 2.

THE GREAT EXHIBITION IN FRANCE.—CONSTRUCTION OF GIFFARD'S MONSTER CAPTIVE BALLOON.

[Continued from SUPPLEMENT No. 126, page 1981.]

THE ART OF PRESERVING THE EYE-SIGHT.

II. VISION.

IF the eye be directed toward yonder tree, the latter apparently produces a sensation; that is, it is seen. If the eye be closed, the sensation ceases.

The eye is, therefore, the organ of sense through which the sensation is produced. It is the organ of the sense of sight. The tree must, therefore, be one of the causes of the impression made upon the eye. But the tree is at such a distance that it cannot itself act on the eye; yet *something* must act, and something must be caused to act on the eye by the tree. That *something* is called

Light.

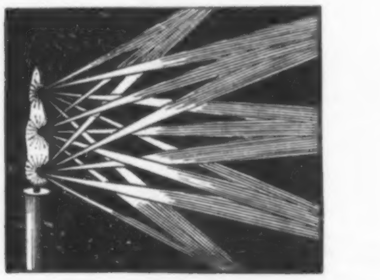


FIG. 10.—RAYS FROM A CANDLE FLAME.

The general consideration of the laws of light belongs to the science of *optics*, some of the fundamental principles of which it will be necessary to indicate before we can understand "how we see."

Two theories have been proposed to account for the phenomena of light; the one most generally accepted is called the *undulatory theory*. This hypothesis supposes that all space, and all the interstices of all material objects, are pervaded by an elastic medium, or ether, of inconceivable tenuity. This medium is not light itself, but is susceptible of being thrown into vibrations, or undulations, by impulses

FIG. 11.—LIGHT REFLECTED BY A MIRROR.

incessantly emanating from all luminous bodies; these, reaching the eye, affect the optic nerve, and produce the sensation we call light. A ray of light emitted from a luminous body proceeds in a straight line, and with extreme velocity. It takes but eight minutes and fifteen seconds to reach us from the sun, and must therefore travel over no less a space than 200,000 miles in a second of time. When light falls upon any object, it may be disposed of in one of three ways: 1st, it may be *reflected*; 2d, it may be *absorbed*; 3d, it may be *transmitted*, or pass through the body.

Every one knows that light may be decomposed; indeed the immortal Newton, the first to investigate this re-

FIG. 12.—PARALLEL RAYS.

markable fact, distinguished seven different colors—violet, indigo, blue, green, yellow, orange, red. This decomposition is effected by passing a beam of light through a glass prism. It is to a decomposition of light that the rainbow is due. Natural bodies possess the power of extinguishing or, as it is called, *absorbing* the light that enters them. This power is selective, hence arise the phenomena of color. When light is *wholly* absorbed the body is black; a body which absorbs all the waves equally, but not totally, is gray; while a body which absorbs the various waves unequally is *colored*.

The seven different rays of light, when once separated by a prism, are not capable of being analyzed by refrac-

FIG. 13.—DIVERGENT RAYS.

tion again; but they can, by means of a convex lens, be collected together and conveyed to a focus and form white light. In revolving a disk, containing the seven colors, swiftly before our eyes, the disk appears white; our separate impressions become confounded through the swiftness, and the white results from the rapid mixing of the colors.

As we have before remarked, light is emitted from bodies in rays; an assemblage of these is called a *pencil*. Rays of light proceeding from a luminous body diverge, or spread out from each other in every direction. It is thus that light proceeds from a candle (Fig. 10). When light is reflected, for instance in falling on a mirror (Fig. 11, B) or other reflecting surface, the ray (Fig. 11, D) will be reflected off at the same angle (Fig. 11, C), or, in other words, the *angle of incidence will be equal to the angle of reflection*.

There are three kinds of rays to be considered: *parallel*, which always proceed in the same direction without meeting (Fig. 12); *divergent* rays, which spread out from the point from whence they proceed (Fig. 13); and, finally, *convergent rays*, which are all directed toward the same point (Fig. 14).

Besides the reflection of light, it is necessary, also, to examine *refraction*, for the laws concerning this are those that will be most useful to us. When a ray of light passes

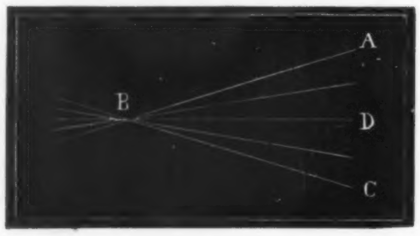


FIG. 14.—CONVERGENT RAYS.

from a rarer to a denser medium (for example, from air into glass), the ray is bent or refracted toward a line perpendicular to that point of the surface on which the light falls. Thus, the ray C (Fig. 15), meeting a plate of glass, V, is broken and bent toward the perpendicular B. The ray C', passing from the glass into the air, is bent in the opposite direction, or *from* the perpendicular, B'.

It is for this reason that a stick partly immersed in water

FIG. 15.—LIGHT REFRACTED BY GLASS.

appears to be broken or bent at the point of immersion, and that bodies beneath the water deceive us as to the exact spot in which they lie. Let us now examine the forms of the

Lenses

employed in optics. Three kinds are distinguished: the *plane*, which allows of objects being seen under their true forms and dimensions; the *convex*, which increases the size of objects; and the *concave*, which diminishes them. By combining these three we obtain six principal forms of lenses—three with thin, convergent edges, and three with

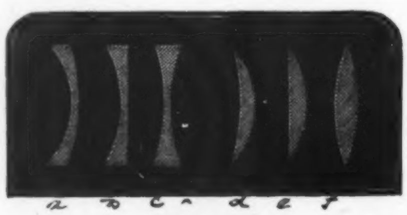


FIG. 16.—LENSES.

a. Concavo-convex. *b.* Plano-concave. *c.* Double-concave. *d.* Convexo-concave. *e.* Plano-convex. *f.* Double-convex.

thick, divergent edges. These forms of lenses are represented in Fig. 16.

A straight line drawn through the center of a lens, and perpendicular to its two convex surfaces, is the *principal axis* of the lens.

A luminous beam falling on a convex lens parallel to the axis has its constituent rays brought to intersection at a point in the axis behind the lens. This point is the *principal focus* of the lens. As before, the principal focus is the focus of parallel rays. Thus the ray R' C (Fig. 17), which passes through the center of the lens, L L', continues on its

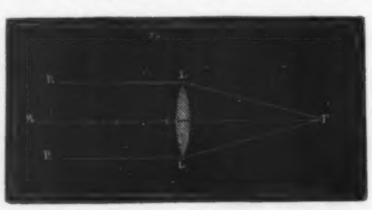


FIG. 17.—PRINCIPAL FOCUS.

way; but the rays R" L' are refracted and intercross at a point, F, situated on a prolongation of the axis R' F. The point F is the *principal focus*. If the rays received on the lens are divergent, instead of parallel, we will then have a *conjugate focus*.

The following is an explanation of this:

The rays R L, R L' (Fig. 18), diverging from the point R, meet the surface of the lens L L', whose principal focus is at O; refracted by the glass, they converge toward the point F, where they intercross in forming an image of the point B.

If the radiating point B (Fig. 17) approaches the lens, the focus F will become more distant, and *vice versa*, but these changes take place according to certain rules.

Let us suppose that the point R (Fig. 18) be moved to P placed twice as far from C as O'; the focus F will move to P', at a distance, C P', equal to C P. But if R were at O', the refracted rays would become parallel, and there would be no image formed. Finally, if R were placed between O' and C', the rays would diverge after refraction. We would then have a *virtual focus*. We may consider indifferently as a focus the point F or the point R; now if the radiating point is at F, its image will form at R as the latter forms at F when the former is at R. It is to this coincidence that has been given the name of *conjugate-foci*. It is very important that we should familiarize ourselves with this very simple theory, for it is the key to effects produced by optical instruments: but it is already understood that the nearer the object O or O' approaches the lens, the more

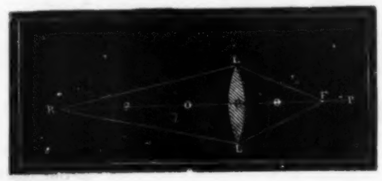


FIG. 18.—CONJUGATE FOCI.

the refracted rays diverge, and consequently the more distant will be the focus.

In speaking of convex lenses, we have said that they had the property of uniting the parallel rays at a point called the principal focus, but we will add here that this reunion takes place only in the rays very near the axis; as for the others, they unite at a small distance before the focus, and the more convex the lens is, the more this phenomena becomes perceptible. Images, then, are clearly defined only toward their center. This imperfection of convex lens is termed *spherical aberration by refraction*. The luminous surfaces formed by the intersection of the refracted rays are called *caustics by refraction*. This defect is partially obviated by placing before the lenses diaphragms provided with a central aperture, which admits the rays passing near the center, but cuts off those passing near the edges.

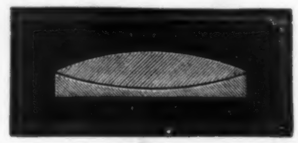


FIG. 19.—ACHROMATIC LENS.

The scientist Euler resolved the problem of destroying the color produced by lenses; then Hall, of England, applied the principle to spectacles; and he was shortly followed by Dollond.

Achromatism is effected by combining together, according to certain rules, two kinds of glass—"crown" and "flint." Every achromatic glass is formed, then, of two kinds of glass which may, or may not, be united by cementation (Fig. 19). The explanation of achromatism is easy to understand. We will take here two prisms to explain this

FIG. 20.—DISPERSION NEUTRALIZED.

curious fact. Let two prisms, F and C (Fig. 20), be placed side by side, turned in a contrary direction. Let us suppose in the first case that both prisms are of the same material, but that the refracting angle of the second is less than that of the first; the two prisms will produce the same effect as a single one, and the light will not only be refracted but also decomposed. If on the contrary the first prism, C, were of crown glass and the other, F, of flint glass, the dispersion might be destroyed without destroying the

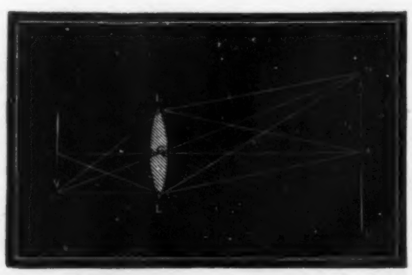


FIG. 21.—INVERSION OF IMAGE.

refraction. For as flint glass is more dispersive than crown, and as the dispersion produced by a prism diminishes with its refracting angle, it follows that by suitably diminishing the refracting angle of the flint glass prism as compared with the refracting angle of the crown glass prism, the dispersive power of these prisms may be equalized; and as from their position the dispersion takes place in a contrary direction, it is neutralized, that is, the emergent rays, R V, give white light. Nevertheless the ratio of the angles of the

prisms C and F, which is suitable for the parallelism of the red and violent rays R and V., is not so for the intermediate rays, and, consequently, only two of the rays of the spectrum can be exactly combined, and the achromatism is not quite perfect. To obtain the latter, several prisms would be necessary, of unequally dispersive materials.

We can best understand the theory of the formation of images through lenses by a reference to what is known as the *camera obscura*. This is, as its name implies, a closed space impervious to light. There is, however, a small aperture through which the luminous rays enter. The ray, proceeding from external objects, and entering by this aperture, forms on the opposite side an image of the object in its natural colors, but of reduced dimensions,

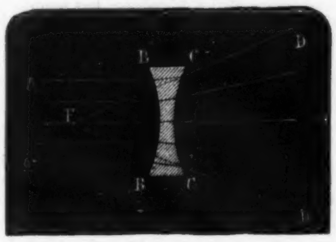


FIG. 22.—ACTION OF DOUBLE CONCAVE LENS.

and in an inverted position. Porta, a Neapolitan physician, the inventor of this instrument, found that by fixing a double convex lens in the aperture, and placing a white screen in the focus, the image was much brighter, and more definite. Let L L (Fig. 21) be a double convex lens, and M N a luminous object, all parts of which throw out divergent rays which intercross in all directions; let us take, for example, three rays proceeding from the center, three from the top, and three from the bottom; these rays entering the lens, L, will be refracted toward the points *n a m*, where will appear the image *n m* of the object N M. This figure explains perfectly the inversion of the image, and will likewise show the relation which exists between the distance of the object and the size of the image. In reality, *m n* is to M N as the distance *c a* is to the distance *c* A. We will close our remarks on optical instruments by saying that in concave lenses (Fig. 22) the rays A A′, falling on one of the surfaces, will be rendered divergent, D D′, and will tend to separate more and more. On prolonging the refracted rays, they

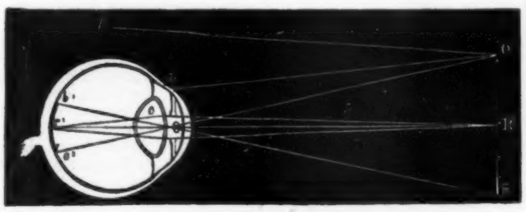


FIG. 23.—THE EYE A CAMERA OBSCURA.

will unite at a point, F, which will be their *virtual focus*. Let us now pass on to the subject of

Vision.

The art of photography has become so popular that there is perhaps no one who is unacquainted with that indispensable instrument—the *camera*. Now the eye is a true *camera obscura;* the crystalline represents the object lens, and the retina the screen upon which the image is thrown.

Let us then examine a section of the eye and see how the rays of light act upon it.

As may be seen, the rays O B, (Fig. 23), proceeding from an object, cross each other and go to form their image in the back part of the eye, at *o′ b′*. These rays form cones, whose points are found at O B, and whose bases rest on the anterior portion of the cornea. The very divergent rays, Op, Op′, falling outside of the circle are lost on the vision.

Can any one fail to be at once struck with the analogy that exists between the *camera obscura* and the human eye? The lens of the instrument is represented by the transparent media of the organ, and principally by the crystalline lens;

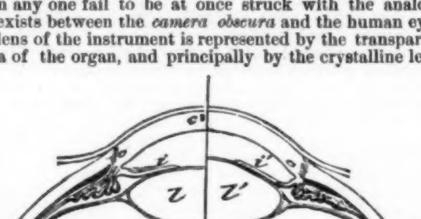


FIG. 24.—ADJUSTMENT TO DISTANCE.

the screen by the retina; the black coating that is applied to the interior of the camera by the choroid coat. The lenses used in optics are subject to certain imperfections, among which we will cite at present only spherical aberration. What is done to remedy this defect? We place before or behind the lens a circle more or less open, with shapely defined edges to intercept the rays; in other words, a *diaphragm* to prevent the passage of such rays as might distort the image. Now, have we not in the eye a diaphragm much more perfect in the iris, which is fitted to perform all the dilations and contractions necessary for perfect vision? It would be superfluous to point out further striking analogies.

If it be asked of what use are the different humors associated with the crystalline lens, we answer (without seeking to give a definite explanation of a problem that has so many times occupied the attention of physicians) that an image clear and free from abnormal coloration can be obtained only by means of several kinds of glass placed in juxtaposition, and that we would fain believe, with the celebrated Euler, that nature has desired to accomplish the same object by the association of these humors of different densities.

It is thus that vision takes place in the normal eye, which is constructed in such a way that it can perceive with equal distinctness objects that are close by or very distant. It adapts itself then to all distances. For objects that are near by this power of adaptation operates within certain limits; thus, if the object be so near the eye, say within 6 inches, that the convergent power of the lens fails to bring the pencils of light to a focus, no distinct perception takes place, but only a sense of light or brightness to a greater or less degree. The least distance at which objects can be distinctly seen is termed the limit of distinct vision; it is, for different eyes, between 6 and 12 inches. Any person who can read without fatigue the type with which this page is printed, at a distance of, say, 12 inches from the eye, may be regarded as having normal eye-sight, and we will use this

FIG. 25.—CHROMATIC EFFECT OF CONES.

distance as a base for the measurement of long-sightedness (*presbyopia*) and short-sightedness (*myopia*).

As regards the cause which allows the eye to adapt itself to different distances, it is probable, from the experiments of Cramer, that the curvature of the crystalline lens changes according to the distances of the objects that are looked at. By means of *Brucke's Muscle* the lens becomes more convex (Fig. 24, *l′*) for objects near by or more flattened (*l*) for those that are distant. It is curious that Descartes, as long ago as 1650, in his Treatise on Man, indicated and figured this change of the lens, and specified that the ciliary processes were small tendons which modified its curve. Hartsoeker, in 1694, held the same theory, but the experiments of Cramer, who *saw* what Descartes had suspected, confirmed the whole matter.

The inversion of images in the eye (Fig. 23) has greatly occupied both physicists and physiologists, and many theories have been proposed to explain how it is that we do not *see* the images thus inverted. Some have supposed that it is by custom, and by a regular education of the eye, that we see objects in their true position, that is, in their position relative to us. The visual impression becomes corrected by the impression of other senses, such as that of touch. Müller, Volkmann, and others contended that, as we see everything inverted, and not simply one object among others, nothing can appear inverted, because terms of comparison are wanting. It must, however, be admitted that none of these theories are quite satisfactory.

We will bring this chapter to a close by describing an ingenious theory of Dr. Galesowski to account for the eye's perception of colors. He believes that the cones of the retina are the chromatic organs. In physics, if we throw a ray of light on a cone of glass (Fig. 25, A), we obtain a circular spectrum such as that represented at B. If white light impinges on a cone of the retina, it will be decomposed; but as the seven colors will produce a simultaneous impression, only white light will be seen. Dr. Galesowski afterward describes how the alteration of the cones explains why certain persons see only red, green, or other colors of the chromatic scale.

THE NEW SYSTEM OF NUMBERING SPECTACLE LENSES.

UNDER the present system of numbering lenses the so-called number is the length measured in inches of the radius of the equal spherical surfaces which limit the mass of crystal constituting the biconvex or biconcave lens under consideration. The two varieties are distinguished by the sign + for converging and — for diverging lenses. When the radius does not measure an exact number of inches the custom is to express the difference, not in lines, as would be logical, but in fractions, as ¼, ½, ¾, etc. It results from the formula which gives the focal distance of a lens, and from the index of refraction of the substance employed, that the radius of the spherical surface is nearly equal to the focal distance, so that approximately the latter is also represented by the number of the spectacle glass or other lens.

While under certain circumstances a knowledge of this focal distance may be convenient or useful, one difficulty in the present system of numbering is non-uniformity in all countries. On the other hand, among the most used formulæ relating to lenses, the focal distance does not intervene directly, but inversely, whether the question be the determination of conjugate foci or (and of more importance from an ophthalmological point) the determination of the power of an optical system constituted by the superposition of two lenses. It is easily demonstrated that if f and f' represent the focal distances of the two lenses and F that of the system, then $\frac{1}{F} = \frac{1}{f} + \frac{1}{f'}$. The adding of the two fractions becomes inconvenient when calculations are frequent, and especially when the members of the lenses or their focal distances are themselves expressed in fractional numbers.

It has recently been decided in Europe, according to the recommendation of the International Medical Congress held at Brussels in 1875, to substitute a system of numbering of which the following are the principles: 1. The lenses are characterized no longer by their focal distances, but by their power, the latter being the inverse of the focal distance since the refracting power is the greater the nearer the focus approaches the lens. 2. The lengths are valued in meters and decimal fractions of the same. The unit of refracting power has received the name of *dioptrie*, and is that which corresponds to a converging lens of 1 meter focus. The measure of the power of a lens in *dioptries* is obtained by dividing unity by the focal distance in meters. Thus lenses having focal distances of 2 : ·5 : ·33 meters have powers which are respectively 0·5 : 2 : and 3 dioptries, and are characterized by the numbers 0·5 : 2 : 3. The difference of signs is kept the same as in the old system.

From the foregoing it is easy to see that the power of a compound system is the algebraic sum of the powers of its members. For example, two converging lenses, of which the numbers in dioptries are + 2 and + 5, constitute a system of power + 7; if the numbers are + 5 and — 3, the system will have + 2 for its number. The focal distance, moreover, of any lens, if not directly given by the number, is easily obtained by dividing 1 meter by the number.

The reciprocal transformation of old into new notation is readily accomplished. M. Gariel points out in *La Nature* that it depends upon the relation of the units, meter and inch, and on the index of refraction of the substances employed, and is done simply by dividing 40 by the number to be transformed. The old number of a lens being 8, for example, its new number would be $\frac{40}{8} = 5$; that is to say, its power will be 5 dioptries and its focal distance 1 meter : 5 = 0 meter ·20. Reciprocally, a lens having for number 10 dioptries (that is, its focal distance is $\frac{1 \text{ meter}}{10} = \cdot 1$ meter) corresponds to one of old number $\frac{40}{10} = 4$. Lens may exist corresponding all degrees of power valued in dioptries; but in the collections used for ophthalmological purposes it suffices to have a certain number of distinct glasses (convergent and divergent). Those which have been adopted as answering all practical needs have the following numbers: 0·25 : 0·5 : 0·75 : 1 : 1·25 : 1·50 : 1·75 : 2 : 2·25 : 2·50 : 3 : 3·50 : 4 : 4·50 : 5 : 5·50 : 6 : 7 : 8 : 9 : 10 : 11 : 12 : 13 : 14 : 15 : 16 : 17 : 18 : 19 : 20.

METROPOLITAN STENCHES.

MR. THOMAS B. MUSGRAVE, as chairman of a citizens' committee, has lately published a report concerning the slaughter houses, bone-boiling factories and other stench-producing establishments which abound on the water front of this city. It would hardly be credited by any one unfamiliar with the manner in which this metropolis is misgoverned that there are periods when stenches of the foulest and most repulsive nature pervade not merely the crowded and unclean localities inhabited by the poor, but that portion of the city which constitutes the most fashionable quarter, where dwellings are palaces and the value of property is highest. This state of affairs has been going on for years. In the hottest summer weather it is often necessary to choose between nauseation by odors or suffocation indoors with closed windows. The result is shown by a mortality average higher for the last ten years in this city than in any other city of fourteen of the largest in the Union, and in the fact that certain localities well adapted for residences are now practically uninhabitable and sources of loss to the owners of dwellings therein.

Mr. Musgrave adduces a severe indictment against the health authorities, bringing forward instance after instance, not merely where these deleterious industries have been carried on with official knowledge, but under the protection of official sanction.

The revelations he makes are, however, no news to those who having suffered under the infliction have investigated for themselves, and they therefore represent simply general opinion put in concrete form. The answer of the Board of Health is in the form of a general denial, mainly based on the allegations of a couple of subordinates, in whose districts these evils have been allowed to continue and flourish, and in the assertion that the majority of the odors are wafted across the river from points beyond the Board's jurisdiction.

This reply will go for nothing to all who, like Mr. Musgrave and the writer of this, have taken the trouble to examine, however superficially, into the true causes of the stenches But so long as the slaughter house people can control their ward politics, hoodwink inspectors, and render nugatory such ordinances as that brought forward a couple of years ago, which relegated all their establishments to the upper part of the island, no relief from the present condition of affairs can reasonably be expected.

THE COMMUNE SCARE.

VARIOUS sensational journals throughout the country have recently been indulging in reports of the organizing of bodies of discontented workingmen, whom, it is alleged, propose to incite riot and emulate the outrages of the Paris Commune, with the hope of thus bettering their condition. This is simply one of those devices whereby newspapers are sold when news is scanty. There is in every city, and especially in New York, where the population is so cosmopolitan, a percentage of worthless vagabonds who come hither usually to avoid the disagreeable attentions of the police at home. These men are natural enemies to society, regardless of its form of government, and they are always to be found in the front of every lawless demonstration. During strikes they act the part of demagogues, incite people to violence, or commit it themselves, and thus bring discredit and popular detestation upon movements that are intrinsically legitimate enough and perhaps well founded. While we advise respectable workingmen to give these agitators a wide berth under all circumstances, it seems entirely needless to warn any one against being led by them into wholesale riot. We have two potent safeguards in this country against either the anarchy of communes or the despotism of dictatorships, and these are the schoolhouse and the press. So long as education remains as widespread as it now is among the masses, and so long as every intelligent laborer is kept by the omnipresent newspaper well posted in current events, we have no fear that the shallow reasoning of a criminal gang will lead any man into the excesses which end in the destruction alike of the community and the individual.

ACID OF THE GASTRIC JUICE.—M. CH. RICKET.—The hydrochloric acid of the gastric juice occurs combined with tyrosin, leucin, and perhaps with other analogous bodies. Hence the gastric juice contains in reality a salt, formed of a feeble base, derived from the albuminoid matters.

ELECTRICITY.

RECENT REMARKABLE IMPROVEMENTS APPLICABLE TO THE TELEPHONE, THE MEASUREMENT OF HEAT, SOUND, ETC.

WE present herewith descriptions of recent electrical improvements relating to the production of sounds by electricity, which appear to contain the germs of a new and remarkable group of electrical instruments.

The honors as first discoverer of these seemingly wonderful improvements belong to Mr. Thomas A. Edison, author of the phonograph; and he also first published the discovery to the world. But Prof. Hughes now comes forward as a claimant to substantially the same discovery. It is a curious circumstance that both of these authors are American citizens, and both are electricians of distinguished ingenuity. The discovery of Mr. Edison was some time ago described here. See, for example, SCIENTIFIC AMERICAN, July 17, 1877. The claims of Mr. Hughes, who is now abroad, were lately presented as original by him before the Royal Society. We presume he will see the propriety of publishing a disclaimer.

We subjoin the following descriptions of the conflicting discoveries, the one that of Mr. Edison's invention, as lately published in the *Journal of the Telegraph* of this city; the other the recent communication of Prof. Hughes to the Royal Society, for which we are indebted to the author.

[FROM THE JOURNAL OF THE TELEGRAPH, April 16, 1878.]

EDISON'S CARBON TELEPHONE.

SUCCESSFUL OPERATION BETWEEN NEW YORK AND PHILADELPHIA.

THE improvement in the Telephone made by Mr. Thos. A. Edison, of Menlo Park, N. J., which increases the power of the instrument by varying the strength of the battery cur-

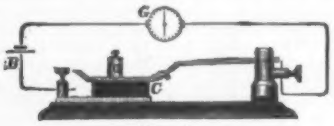


FIG. 1.

rent in unison with the rise and fall of the vocal utterance, was very successfully tested on the 4th inst. on the Western Union line between New York and Philadelphia.

Mr. Edison's experiments with the speaking telephone were begun in or about July, 1875. He was at that time experimenting with a system of multiple telegraphy, which had for its basis the transmission of acoustic vibrations. Being furnished at the same time by Hon. William Orton, President of the Western Union Telegraph Company, with a description, translated from a foreign scientific journal, of Reiss' telephone, he began a series of experiments with the view of producing an articulating telephone.

His experiments resulted in the invention of the improvement known as the Carbon Telephone, the following description of which we are kindly allowed to copy from advance sheets of Mr. Geo. B. Prescott's work, "The Speaking Telephone and Other Electrical Novelties," now in press, and shortly to be issued by Messrs. D. Appleton & Co., publishers, of this city:

"The Edison telephone, like that of Mr. Elisha Gray, is based upon the principle of varying the strength of a battery current in unison with the rise and fall of the vocal utterance. The problem of practically varying the resistance controlled by the diaphragm, so as to accomplish this result, was by no means an easy one. By constant experimenting, however, Mr. Edison at length made the discovery that, when properly prepared, carbon possessed the remarkable property of changing its resistance with pressure, and that the ratios of these changes, moreover, corresponded exactly with the pressure. Fig. 1 represents a convenient and ready way of showing the decrease in resistance of this substance when so subjected. The device consists of a carbon disk, two or

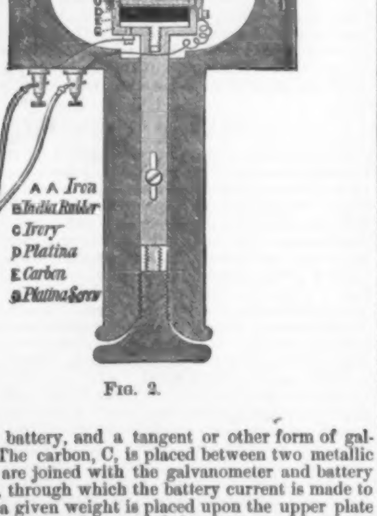


FIG. 2.

three cells of battery, and a tangent or other form of galvanometer. The carbon, C, is placed between two metallic plates, which are joined with the galvanometer and battery in one circuit, through which the battery current is made to pass. When a given weight is placed upon the upper plate the carbon is subjected to a definite amount of pressure, which is shown by the deflection of the galvanometer needle through a certain number of degrees. As additional weight is added, the deflection increases more and more, so that by carefully noting the deflections corresponding to the gradual increase of pressure we can thus follow the various changes of resistance at our leisure. Here, then, was the solution; for, by vibrating a diaphragm with varying degrees of pressure against a disk of carbon, which is made to form a portion of an electric circuit, the resistance of the disk would vary in precise accordance with the degree of pressure, and consequently a proportionate variation would be occasioned in the strength of the current. The latter would thus possess all the charcteristics of the vocal waves, and by its reaction through the medium of an electro-magnet might then transfer them to another disk, causing the latter to vibrate, and thus reproduce audible speech.

"Fig. 2 shows the telephone as constructed by Mr. Edison. The carbon disk is represented by the black portion, E, near the diaphragm, A A, placed between two platinum plates, D and G, which are connected in the battery circuit, as shown by the lines. A small piece of rubber tubing, B, is attached to the center of the metallic diaphragm, and presses lightly against an ivory piece, C, which is placed directly over one of the platinum plates. Whenever, therefore, any motion is given to the diaphragm, it is immediately followed by a corresponding pressure upon the carbon and by a change of resistance in the latter, as described above. The object in using the rubber just mentioned is to dampen the movement of the disk, so as to bring it to rest almost immediately after the cause which put it in motion has ceased to act; interference with articulation, which the prolonged vibration of the metal tends to produce in consequence of its elasticity, is thus prevented, and the sound comes out clear and distinct. It is obvious that any electro-magnet, properly fitted with an iron diaphragm, will answer for a receiving instrument in connection with this apparatus.

"Fig. 3 shows a sending and receiving telephone and a box containing the battery.

"In the latest form of transmitter which Mr. Edison has introduced the vibrating diaphragm is done away with alto-

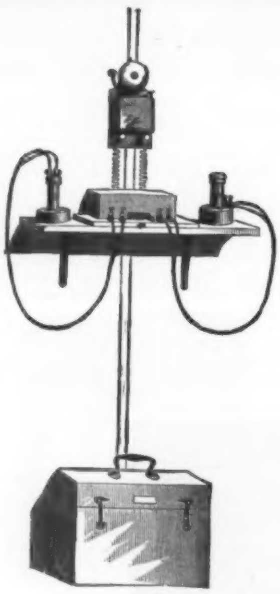


FIG. 3.

gether, it having been found that much better results are obtained when a rigid plate of metal is substituted in its place. With the old vibrating diaphragm the articulation produced in the receiver is more or less muffled, owing to slight changes which the vibrating disk occasions in the pressure, and which probably results from tardy dampening of the vibrations after having been once started. In the new arrangement, however, the articulation is so clear and exceedingly well rendered that a whisper even may readily be transmitted and understood. The inflexible plate, of course, merely serves, in consequence of its comparatively large area, to concentrate a considerable portion of the sonorous waves upon the small carbon disk or button; a much greater degree of pressure for any given effort on the part of the speaker is thus brought to bear on the disk than could be obtained if only its small surface alone were used.

"The best substance so far discovered for these disks is lampblack, such as is produced by the burning of any of the lighter hydro-carbons. Mr. Edison has found, however, that plumbago, hyperoxide of lead, iodide of copper, powdered gas retort carbon, black oxide of manganese, amorphous phosphorus, finely divided metals, and many sulphides may be used; indeed, tufts of fiber, coated with various metals by chemical means and pressed into buttons, have also been employed, but they are all less sensitive than the lampblack, and have consequently been abandoned for the latter substance."

The telephone trials referred to were made between the Western Union Telegraph building in this city, President Orton, Mr. E. S. Sanford, Mr. Edison, Mr. G. M. Phelps, Jr., and others being present, and the office of Mr. Henry Bentley, President of the Local Telegraph Company in Philadelphia, where there were assembled Mr. Bentley, Sup't Merrihew, of the Western Union Telegraph Company, Mr. G. M. Phelps, and a number of others, to test the apparatus, as also the magneto-telephone of Mr. G. M. Phelps.

The circuit used was 106 miles in length, the line passing through a maze of wires, crossing five streams in cables, and in New York passing underground to the Western Union office, which it enters with a mass of other wires. The experiments were highly successful, the carbon transmitter working perfectly, every word spoken at one end of the line being clearly articulated at the other. A number of receivers were attached to the line in Philadelphia, some of them being of the Phelps magneto pattern. The latter received just as clearly and distinctly as the others from the carbon transmitter. The conversation was maintained for some time, and lines of a song sang into the transmitter in New York were received with surprising accuracy in Philadelphia.

The Phelps magneto-telephone was also tried, and some transmissions by it were plainly heard, but the interference from the other wires affected it more seriously than it did the carbon, and the result was less satisfactory than with the latter.

TELEPHONIC TRANSFORMATIONS.

M. A. DEMOGET, of Nantes, estimates that only about $\frac{1}{1366}$ of the sound which is communicated to the telephone is transmitted to the receiver. He considers that the muscular effort of the speaker is transformed: 1, into vibrations of the air; 2, into metallic vibrations; 3, into magnetic waves; 4, into electric induction; 5, into magnetic induction; 6, into metallic vibrations; 7, into vibrations of the air; 8, into vibrations of the auditory apparatus. If we suppose the loss of useful effect at each transformation to be equal, the loss would be comprised between $\frac{2}{3}$ and $\frac{1}{2}$. This represents, very nearly, the experimental efficiency of pumps.—*Les Mondes.*

[Read before the Royal Society, London, May 9th, 1878.]

ON THE ACTION OF SONOROUS VIBRATIONS IN VARYING THE FORCE OF AN ELECTRIC CURRENT.

By PROF. D. E. HUGHES.

Communicated by PROF. HUXLEY, F.R.S., etc. Received May 8, 1878.

THE introduction of the telephone has tended to develop our knowledge of acoustics with great rapidity. It offers to us an instrument of great delicacy for further research into the mysteries of acoustic phenomena. It detects the presence of currents of electricity that have hitherto only been suspected, and it shows variations in the strengths of currents which no other instrument has ever indicated.

It has led me to investigate the effect of sonorous vibrations upon the electrical behavior of matter. Willoughby Smith has shown that the resistance of selenium is affected by light, and Börnstein has led us to believe that many other bodies are similarly affected. We know also that the resistance of all bodies is materially influenced by heat. Sir William Thomson and others have shown that the resistance to the passage of currents offered by wires is affected by their

Fig. 1.

being placed under strains, and, inasmuch as the conveyance of sonorous vibrations induces rapid variations in the strains at different points of a wire, I believed that the wire would vary in its resistance when it was used to convey sound. To investigate this I made a rough-and-ready telephone, with a small bar magnet four inches long, half the coil of an ordinary electro-magnet, and a square piece of ferrotype iron, three inches square, clamped rigidly in front of one pole of the magnet between two pieces of board. When using the pendulum beats of a small French clock, or the voice, as a source of sound, I found this arrangement supplied me with an extremely delicate *phonoscope* or sound detector.

All the experiments detailed in this paper were made with the simplest possible means, and no apparatus of any kind constructed by a scientific instrument maker was employed. The battery was a simple Daniell's cell, of Minotto's form, made by using three common tumblers, a spiral piece of copper wire being placed at the bottom of each glass and covered with sulphate of copper, and the glass being then filled with well-moistened clay and water. A piece of zinc as the positive element was placed upon the clay. Insulated wires were attached to each plate, and three of these cells were joined in series. All experiments were made on a closed circuit, the telephone being used as a phonoscope to detect variations in the current and the consequent reproduction of sound. The apparatus or materials experimented upon were used in the same way as the transmitter of the speaking telephone of Bell. The attached sketch, Fig. 1, will make this clear. B is the battery, S the source of sound or material examined, T the telephone or phonoscope.

I introduced into the circuit at S a strained conductor—a stretched wire—listening attentively with the telephone to detect any change that might occur when the wire was spoken to or set into transverse vibrations by being plucked aside. Gradually, till the wire broke, the strain was varied, but no effect whatever was remarked except at the moment when the wire broke. The effect was but momentary, but invariably at the moment of breaking a peculiar "rush" or sound was heard. I then sought to imitate the condition of the wire at the moment of rupture by replacing the broken ends and pressing them together with a constant and varying force by the application of weights. It was found that if the broken ends rested upon one another with a slight pressure of not more than one ounce to the square inch on the joints, sounds were distinctly reproduced, although the effects were very imperfect.

It was soon found that it was not at all necessary to join two wires endwise together to reproduce sound, but that any portion of an electric conductor would do so even when fastened to a board or to a table, and no matter how complicated the structure upon this board, or the materials used as a conductor, provided one or more portions of the electrical conductor were separated and only brought into contact by a slight but constant pressure. Thus, if the ends of the wire, terminating in two common nails laid side by side and separated from each other by a slight space, were electrically connected by laying a similar nail between them, sound could be reproduced. The effect was improved by building up the nails log-hut fashion, into a square configuration, using ten or twenty nails. A piece of steel watch chain acted well. Up to this point the sound or grosser vibrations were alone produced; the finer inflections were missing, or, in other words, the *timbre* of the voice was wanting; but in the following experiments the *timbre* became more and more perfect until it reached a perfection leaving nothing to be desired. I found that a metallic powder such as the white powder—a mixture of zinc and tin—sold in commerce as "white bronze," and fine metallic filings, introduced at the points of contact, greatly added to the perfection of the result.

At this point articulate speech became clearly and distinctly reproduced, together with its *timbre*, and I found that all that now remained was to discover the best material and form to give to this arrangement its maximum effect. Although I tried all forms of pressure and modes of contact—a lever, a spring, pressure in a glass tube sealed up while under the influence of strain—so as to maintain the pressure constant, all gave similar and invariable results, but the results varied with the materials used. All metals, however, could be made to produce identical results, provided the division of the metal was small enough, and that the material used does not oxidize by contact with the air filtering through the mass. Thus platinum and mercury are very excellent and unvarying in their results, while lead soon becomes of such high resistance, through oxidation upon the surface, as to be of little or no use. A mass of bright round shot is peculiarly sensitive to sound while clean, but as the shot soon become coated with oxide this sensitiveness ceases. Carbon again, from its surface being entirely free from oxi-

dation, is excellent, but the best results I have been able to obtain at present have been from mercury in a finely divided state. I took a comparatively porous non-conductor, such as the willow charcoal used by artists for sketching, heating it gradually to a white heat and then suddenly plunging it in mercury. The vacua in the pores, caused by the sudden cooling, became filled with innumerable minute globules of mercury, thus, as it were, holding the mercury in a fine state of division. I have also tried carbon treated in a similar manner with and without platinum deposited upon it from the chloride of platinum. I have also found similar effects from the willow charcoal heated in an iron vessel to a white heat, and containing a free portion of tin, zinc, or other easily vaporized metal. Under such conditions the willow carbon will be found to be metallized, having the metal distributed throughout its pores in a fine state of division. Iron also seems to enter the pores if heated to a white heat without being chemically combined with the carbon as in graphite, and, indeed, some of the best results have been obtained from willow charcoal containing iron in a fine state of division.

Pine charcoal treated in this manner (although a non-conductor as a simple charcoal) has high conductive powers, due to the iron, and, from the minute division of the iron in the pores, is a most excellent material for the purpose.

Any one of these preparations confined in a glass tube or a box, and provided with wires for insertion in a circuit, I call a "transmitter."

Reis, in 1860, showed how, by the movement of a diaphragm, intermittent voltaic currents could be transmitted, agreeing in exact number with the sonorous waves impinging on the diaphragm, and thus reproducing music at a distance by causing an electro-magnet to vibrate in unison with the diaphragm; and, with an iron diaphragm, Graham Bell showed how the vibrations of that diaphragm in front of a polarized electro-magnet could similarly induce magneto-currents, corresponding in number, amplitude, and form with the sonorous vibration, and thus reproduce all the delicacies of the human voice. Edison and others have produced variations in the strengths of a constant current by causing the diaphragm to press directly upon some elastic conductor, such as carbon, spongy platinum, etc., the varying pressure upon these materials varying the resistance of the circuit, and consequently the strength of current flowing. Graham Bell and others have produced the same effect, by causing the vibrations of the diaphragm to vary the electromotive force in the circuit. It will be seen, however, that, in the experiments made by myself, the diaphragm has been altogether discarded, resting as it does upon the changes produced by molecular action, and that the variations in the strengths of the currents flowing are produced simply and solely by the direct effect of the sonorous vibrations.

I have found that any sound, however feeble, produces vibrations which can be taken up by the matter interposed in the electrical circuit. Sounds absolutely inaudible to the human ear affect the resistance of the conductors described above. In practice, the effect is so sensitive that a slight touch on the board, by the finger nail, on which the transmitter is placed, or a mere touch with the soft part of a feather, would be distinctly heard at the receiving station. The movement of the softest camel hair brush on any part of the board is distinctly audible. If held in the hand, several feet from a piano, the whole chords—the highest as well as the lowest—can be distinctly heard at a distance. If one person sings a song, the distant station, provided with a similar transmitter, can sing and speak at the same time, and the sounds will be received loud enough for the person singing to follow the second speech or song sent from the distant end.

Acting on these facts, I have also devised an instrument suitable for magnifying weak sounds, which I call a *microphone*. The microphone, in its present form, consists simply of a lozenge-shaped piece of gas carbon, one inch long, quarter inch wide at its center, and one-eighth of an inch in thickness. The lower pointed end rests as a pivot upon a small block of similar carbon; the upper end, being made round, plays free in a hole in a small carbon-block, similar to that at the lower end. The lozenge stands vertically upon its lower support. The whole of the gas carbon is tempered in mercury, in the way previously described, though this is not absolutely necessary. The form of the lozenge-shaped carbon is not of importance, provided the weight of this upright contact piece is only just sufficient to make a feeble contact by its own weight. Carbon is used in preference to any other material, as its surface does not oxidize. A platinum surface in a finely-divided state is equal, if not superior, to the mercurized carbon, but more difficult and costly to construct. I have also made very sensitive ones entirely of iron.

The best form and materials for this instrument, however, have not yet been fully experimented on. Still, in its present shape, it is capable of detecting very faint sounds made in its presence. If a pin, for instance, be laid upon or taken off a table, a distinct sound is emitted, or if a fly be confined under a table-glass, we can hear the fly walking, with a peculiar tramp of its own. The beating of a pulse, the tick of a watch, the tramp of a fly, can thus be heard at least a hundred miles distant from the source of sound. In fact, when further developed by study, we may fairly look for it to do for us, with regard to faint sounds, what the microscope does with matter too small for human vision.

It is quite evident that these effects are due to a difference of pressure at the different points of contact, and that they are dependent for the perfection of action upon the number of these points of contact. Moreover, they are not dependent upon any apparent difference in the bodies in contact, but the same body in a state of minute subdivision is equally effective. Electrical resistance is a function of the mass of the conductor, but sonorous conduction is a function of the molecules of matter. How is it therefore that a sonorous wave can so affect the mass of a conductor as to influence its electrical resistance? If we assume a line of molecules, we know that a sonorous wave is accompanied by alternate compressions and rarefactions. If we isolate the part under compression from the part under dilatation we vary the dimensions of the mass, and we alter its electrical resistance. In any homogeneous conductor of finite dimensions the effect of the one will exactly compensate for the effect of the other, and we get no variation of current, but if we break up this homogeneous conductor into a series of minute subdivisions without actually breaking their electrical continuity we destroy this neutralizing influence, and we render evident the effect of sonorous vibrations in varying the dimensions of the mass of the conductor, and, therefore, in varying its electrical resistance, for we reduce the length of a portion of the conductor to a fraction of the length of a sonorous wave. Molecular action alone explains to me all the effects produced. Size or shape does not affect them. A piece of willow charcoal, the size of a pin's head, is quite sufficient to reproduce articulate speech. I regard the action as follows: If we have two separate conductors joined simply by contact, this contact offers a certain resistance. Now we can vary or lessen the resistance by increasing the pressure, thus bringing more points in contact or closer proximity. Now, as I employ a constant pressure on the contact, which is exactly under the same influence of the vibrations as the points of contact, more points or closer proximity can only be obtained through the molecular swelling or movement of the contact points.

If we assume a line of molecules at the point of contact of the minute masses of conducting matter in their neutral condition to be arranged thus:

OOOOO

they will appear thus under compression:

00000

and thus under dilatation:

ooooo

In the former case the electrical resistance would be *less* and in the latter case *more* than in the normal condition. Hence we should get variation in their electrical resistance, and thus sonorous waves could vary the strength of an electric current, and the variations of the electric current can be made to reproduce sonorous vibrations. These, however, would only produce the result in a certain line, say horizontal; but those perpendicular, while producing the same result, would be a half vibration behind, and thus if two contacts, the one horizontal and the other perpendicular, were on the same piece of charcoal, and the conducting line joined to both, we should have interference. The contrary takes place, as the more contacts we have, and the more varied their direction on the same, the louder and purer the sound becomes. Hence there is no interference, and consequently the whole mass must swell and diminish equally in all directions at the same instant of time.

The tube transmitter, which I exhibit this evening, consists of an exterior glass tube two inches long and one quarter of an inch in diameter. In it are four separate pieces of willow charcoal, each one quarter of an inch long, and two terminals of the same material. The terminals are fastened in the tube, and connect exteriorly with the line and interiorly with the four loose pieces, thus:

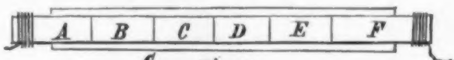


Fig. 2.

Here A is made to press on B, C, D, E, and F, until the resistance offered to the electrical current is about one-third that of the line upon which it is to be employed. It may be attached to a resonant board by the ends A or F. If the result was simply due to vibrations, we should have A and B making greater contact at a different time from E and F, and consequent interference. If it was a simple shaking or moving of B, C, D, E, and F, it could produce no change, as if B pressed more strongly on C, it would be less on A, and also if the tube was attached by the center we should have no effect; but if the effect is due to a swelling or enlargement of B, C, D, E, F, it would make no difference where it is attached to the resonant board, as is actually the case. Again reduce the pressure of A upon B, etc., until they are not in contact, and no trace of current can be perceived by shaking the tube. The instant the sonorous vibrations pass in the tube there is electric contact to a remarkable degree, which could only have taken place by the molecules enlarging their sphere under the influence of the sonorous vibrations.

It is impossible to say what can be the applications or the effects of the discovery which I have had the honor of bringing before the Royal Society, for the whole question has been studied with crude materials, and scarcely sufficient time has elapsed to enable me to consider its ultimate uses. I do not desire to assert that there is anything in what I have brought forward that is superior to or equal to other transmitters used for telephony. It is as loud and far more sensitive than any I have yet heard, and it may be increased by multiplication of transmitting contacts in quantity or intensity; the loudness is at present limited by the capability of the receiver. The materials at my disposal, and the arrangement of them, have not yet been sufficiently studied. I only wished to show that it is possible to transmit clear and intelligent articulate speech, and to render audible sounds which have hitherto been inaudible by the mere operation of sonorous vibrations upon the conducting power of matter.

My warmest thanks are due to Mr. W. H. Preece, electrician to the Post Office, for his appreciation of the importance of the facts I have stated, and for his kind counsel and aid in the preparation of this paper.

I do not intend to take out a patent, as the facts I have mentioned belong more to the domain of discovery than invention. No doubt inventors will ere long improve on the form and materials employed. I have already my reward in being allowed to submit my researches to the Royal Society.

ELECTRIC LIGHT.

M. PETROUCHEVSKY, Russia, has made some experiments with the Jablochkoff electric candle. He measured the intensity of the light given by them. Two specimens of candles were used for this purpose: (1) Candles in which the carbons were divided by gypsum; (2) candles with carbons divided by kaolin. Bunsen's photometer was used. The following are the results:

(1.) *Candles with Gypsum.*

Intensity of Light. (In Stearine Candles.)	Quantity of Revolutions per Minute of Machine.
931	1200
931	1350
1495	2500

(2.) *Candles with Kaolin.*

414	1224
402	1200
517	1222

These experiments show that it is better to divide the carbons of the candles by gypsum; but it was also remarked that the light produced by candles with kaolin has more steadiness and is more agreeable. During these experiments one of Gramme's small magneto-electric machines was in use.

ORIGIN OF SOLAR AND SIDEREAL HEAT.

By Prof. DANIEL KIRKWOOD.

THE *Quarterly Journal of Science* for July, 1877, contains an able and interesting article by James Croll, LL.D., F.R.S., on the age and origin of the sun's heat. The theory of Dr. Croll may be regarded as a compromise between the mathematicians, represented by Thomson, Tait, and Newcomb, and the geologists of the uniformitarian school, represented by Playfair, Lyell, Darwin, etc. The principal points of this remarkable paper are:

1. That, as had been estimated by Sir William Thomson and others, but twenty million years' heat could be produced by the falling together of the sun's mass.

2. That not less than five hundred millions of years have been required for the stratification of the earth's crust at the present rate of subaerial denudation, and hence that the gravitation theory of the origin of the sun's heat is incompatible with geological facts.

3. If we suppose two solid opaque bodies, each equal to half the sun's mass, to fall together in consequence simply of their mutual attraction, the collision would instantly generate sufficient heat to reduce the entire mass to a state of vapor. If, in addition to the motion resulting from their mutual attraction, we suppose the bodies to have had an original or independent motion toward each other of 202 miles per second, the concussion would produce 50,000,000 years' heat; a motion of 678 miles per second, together with that due to their mutual attraction, would generate 200,000,000 years' heat; and a velocity of 1,700 miles per second would generate an amount of heat which would keep up the supply at the present rate for 800,000,000 years.

4. The sun and all visible stars may have derived their heat from the collision of cold, opaque masses thus moving in space. The nebulæ are the products of the more recent impacts, and the stars have been formed by the condensation of ancient nebulæ.

5. This theory, while accepting the doctrine of the conservation of energy, indicates at the same time a possible supply of heat for several hundred millions of years, thus satisfying all moderate demands for geological time.

The mathematical correctness of the theory here stated will not be called in question. We shall consider merely the *probability* of the facts assumed as its basis. To the present writer the hypothesis seems unsatisfactory for the following reasons:

1. The existence of such sidereal bodies as the theory assumes is purely conjectural, unless it be claimed that lost or missing stars have become non-luminous, of which we have no conclusive evidence.

2. But, granting their existence, we have no instances of stellar motion comparable with those demanded by the hypothesis, the velocity being in most cases less than 50 miles and in no case exceeding 200 miles per second.

3. If the two masses by whose collision the sun is supposed to have been formed were very unequal, as would be most probable, the amount of heat generated would be correspondingly less.

4. Such collisions as the theory assumes are wholly hypothetical. It is infinitely improbable that two cosmical bodies should move in the same straight line; and of two moving in different lines, it is improbable that either should impinge against the other. Comets pass *round* the sun without collision against it.

5. But, granting these difficulties removed, let us suppose that about 800,000,000 years ago two cold, opaque bodies, each containing one-half the matter of the solar system, were approaching one another in the same straight line, each at the rate of 1,700 miles per second;* that on meeting, their motion was transformed into heat, and that their united mass was at once reduced to vapor, the great question yet remains, How much of the period represented by these 800,000,000 years' heat can be claimed as *geological* time? The nebula formed by the collision would extend far beyond the present orbit of Neptune. The amount of heat radiated in a given time from so vast a surface would doubtless be much greater than that now emitted in an equal period. No considerable contraction could occur until a large proportion of the heat produced by the impact had been dissipated in space. It has been shown by Trowbridge† that, with a temperature at the sun's surface of twice its present intensity, the solar atmosphere would be expanded beyond the earth's orbit. The conclusion seems inevitable that much the greater part of the 800,000,000 years' heat must have been radiated into space before the planets were separated from the solar mass, and, consequently, that the amount of geological time cannot, to any great extent, have exceeded the limits indicated by the researches of Sir William Thomson.

Upon the whole, it seems more difficult to grant the demands of Dr. Croll's hypothesis than to believe that in former ages the stratification of the earth's crust proceeded more rapidly than at present. The former, as we have seen, has no sufficient basis in the facts of observation. On the other hand, if our planet has cooled down from a state of igneous fluidity, the great heat of former times must doubtless have intensified both aqueous and atmospheric agencies in producing modifications of the earth's exterior.—*American Journal of Science and Arts.*

THE working out of the results obtained by the transit of Venus expeditions sent out by the German government were expected to have been far enough advanced for publication in the year 1877, but it has been found that this task causes more difficulties and expense than had been at first anticipated, and a demand has been consequently made for an extra credit of £500 to defray the additional costs.—*Engineer.*

SPONTANEOUS combustion of substances can only take place when they are so packed that small increments of heat may be stored up. If they are freely exposed to the air the heat evolving action which goes on with it may be increased rapidly; but its effect is dissipated.

PHOTOGRAPHY by electric light is again occupying attention in London, and, it is said, successfully in portrait work, the electric light being thrown from a parabolic reflector through a Fresnel lens upon the sitter. The light is soft and uniform.

* This is the greatest velocity mentioned by Dr. Croll. An increased rate of motion would, of course, produce more heat, but the hypothesis would be open to the same objections.

† Proc. Am. Phil. Soc., vol. xvi., pp. 329-333, and *National Quarterly Review*, March, 1877, p. 292.

ERGOT.

By W. CARRUTHERS, F.R.S.

ERGOT has been observed on a large number of our native and cultivated grasses, as well as on our cereal crops. The grasses that are most subject to its attacks are rye-grass (Lolium perenne, Linn.); the brome-grasses (Bromus secalinus, Linn., B. mollis, Linn., B. Pratensis, Ehr.); couch grass (Triticum repens, Linn.); foxtail grass (Alopecurus pratensis, Linn.); timothy grass (Phleum pratense, Linn.); fescue grass (Festuca elatior, Linn.); barley grass (Hordium murinum, Linn.); and manna grass (Glyceria fluitans R. Br.). With the view of enabling the reader to recognize this pest, which is made too little account of by agriculturists, I have given a number of engravings from remarkably accurate but till now unpublished drawings of its appearance on different plants, made by Francis Bauer, who for several years carefully observed this disease when he was connected with the Royal Gardens at Kew as botanical draughtsman.

The appearance of ergot in rye-grass is well known. A greatly affected head is shown is Fig. 4 of the variety of darnel (Lolium temulentum, Linn.), with very short awns, or altogether without them, which Withering separated as a distinct species, giving to it the name of Lolium arvense. Improved husbandry has made this a comparatively rare grass in cultivated fields, where it is of little value as a forage plant, though not so injurious as it has been called; indeed, recent experiments make it almost certain that the evils reported and believed to have been produced by the use of darnel have been really caused by the unobserved ergot. The frequency with which rye-grass is attacked has often been noticed. Edward Carroll says he never failed to discover it more or less ergotted in fields allowed to stand for seed, and he adds, what appears to be opposed to general experience, that its extent is in proportion to the wet or dry state of the summer months during its maturation, being rarer when wet, frequent when dry. The probable explanation of this reversing of the experience in England and the Continent is that it is due to the normal moist atmosphere of Ireland, where Mr. Carroll made his observations, being fitted for the germination of the spores of fungi, while rain would wash the spores off the plants, and a superabundance of water would be unfavorable to their growth.

A head of timothy grass (Phleum pratense, Linn.) is represented in Fig. 1 with an extraordinary number of ergotted ears. This grass forms a considerable portion of the late meadow crops in many districts.

I have already in the darnel figured the ergot in a weed in cultivated grounds; and in the barley grass (Hordeum murinum, Linn.) (Fig. 2) we have it on one of the most common annual grass weeds of our roadsides and waste places. Although this is a worthless weed, as it is rejected even by the half-starved animals that feed by the roadside, it may be actively injurious to the agriculturist if it is to any extent a nidus for the growth of ergot.

Numerous other illustrations might be given, but our figures of the ergot, as it appears in cereals and in pasture and weed grasses, are sufficient to show the general aspect of this parasitic fungus, and to enable the reader easily to detect it.

No farm or district has any right to hope for exemption from this dangerous pest. It may not have been noticed, or it may have actually been absent for many years, yet it may suddenly, without any obvious cause, appear in great abundance and prove a cause of serious destruction to the cattle or sheep placed in the field where its presence is not suspected.

The true nature of ergot was at length determined by observations first made on its early history and development on the diseased plants, and then by experiments on the ergot itself, with the view of determining its ultimate product. In both directions the most satisfactory results have been arrived at, and we now know the complete history of the plant.

In its earliest condition this parasitic fungus escapes notice, being composed of a large number of very small elongated cells borne in a colorless liquid. In about three days after the plant is attacked the ergot becomes visible, appearing as a yellowish viscous substance resting on the outer coating of the as yet undeveloped attacked grain (Fig. 3). It exudes from between the glumes and more or less completely covers the whole seed. It has a taste like honey and an odor like that of grated bones. The ears naturally attacked do not belong to less vigorous or healthy plants than those that escape.

Once established, the fungus rapidly develops, carrying upward the aborted remains of the seed, crowned with the withered styles, and forming below the homogeneous sclerotioid mass, which becomes the true ergot.

The state of the development of the ergot had been observed early in the century by Bauer, though none of his figures were published till 1841. He had noticed its relation to the outer covering of the seed, and had supposed it to be an altered condition of that structure (*Linn. Trans.*, vol. xviii., p. 475).

Léveillé, in 1826, noticed that the ergot commenced with this soft covering, and considering it to be a distinct fungus, parasitic on the ergot, he proposed for it the name of Sphacelia.

When the ergot attains its full size the sphacelia disappears, or only the withered and dried up remains of it can be detected at the apex of the ergot.

The further history of the ergot has been determined also by Tulasne. The frequent occurrence of minute sphærias on the ergotted grains of grasses suggested to him that they were probably not accidental productions, as had been supposed, but were organically connected with the ergot, and represented a further stage of its development. With the view of testing this opinion, he planted a number of ergotted grains, and had the satisfaction to find that a considerable proportion produced sphærias. Those produced by the ergot of rye were the same in form and structure with what were grown from the ergots of most of the other grasses, and believing them all to belong to the same species, he gave to it the name of Claviceps purpurea (Fig. 3). This perfect plant is a small purplish fungus, with a spherical head, supported on a short firm stem, with a somewhat downy base. The globose head is rough with small prominences, which are the openings of the cavities or conceptacles in which the spores are produced (Fig. 3. *b* and *c*).

Having traced the history of the ergot, we may now inquire how and at what time the crops get infected, with the view of seeing whether it is possible to discover any means of alleviating, if not of destroying, this injurious parasite.

At two different stages in the life of ergot, bodies are produced which have the power of propagating the disease, viz., the spores of the perfect fungus developed from the ergot, or the "spores" (spermatia or conidia) of the early sphacelia state of the parasite.

The plant is carried over the winter in the dormant ergot condition. A large proportion of the ergot in a field, when it is fully ripe, falls to the ground during the operations of the harvest, or by the friction of the spikes against each other through the action of the wind. These ergots remain on the ground during the winter without undergoing any change. They are dormant, like the seeds of plants, until the following spring or summer, when they produce crops of the perfect fungus (Claviceps purpurea, Tul.). The spores of the Claviceps are ripe about the time that the cereals come into flower, and by the action of wind or rain they obtain access to the flowers.

In 1856 Durieu communicated ergot to rye by placing the spores of the Claviceps on its flowers. Roze has since confirmed and extended these observations (*Bulletin Soc. Bot. de France*, 1870).

It is, then, by these minute needle-like spores that the disease is communicated at first to all crops; and the principal effort of the farmer who desires to free himself from this pest should be to secure clean seed perfectly free from ergot. The ergot is too frequently overlooked in the barn from its resemblance to the dung of mice; but it is worth special pains in examining the seed to secure immunity from this parasite. Tulasne states as the results of his experiments that if the ergot does not produce the Claviceps during the first year after it has fallen to the ground, it loses its vital powers. One might hope to find in this observation of Tulasne the means of coping with the disease; and certainly it is most desirable not to follow an ergotted crop with another crop of cereals. But it must be remembered that the same species of fungus produces an ergot in most of our grasses, and that the spores belonging to the Claviceps of these grass ergots will as readily communicate the disease to cereals as those produced by the cereals themselves. We may, therefore, have in ergotted grasses growing in the margin of fields or along hedgebanks the means of maintaining and spreading the disease in cereal crops. No trouble should be spared to collect and destroy the ergots on such grasses. To permit them to fall to the ground is a certain method of securing the appearance of the disease on any cereal or grass crops in the neighborhood in the following year.

But the disease having once appeared in a field of growing grain, or among hay or grass, easily spreads itself in its early sphacelia state. Every one of the "spores" (spermatia) has the power, as we have seen, of germinating, and so spreading the disease. The striking of an ergotted head against a healthy plant will communicate the disease. This has been experimentally tested by Bonorden and confirmed by Roze. It is not possible, however, to interpose at this stage of the malady with the view of arresting it. The diseased grains are difficult to discover in the field, and it would be hopeless to attempt to pick them out. The disease can only be effectually dealt with while the plant is in its dormant state as an ergot, as already pointed out.—*Agricultural Gazette.*

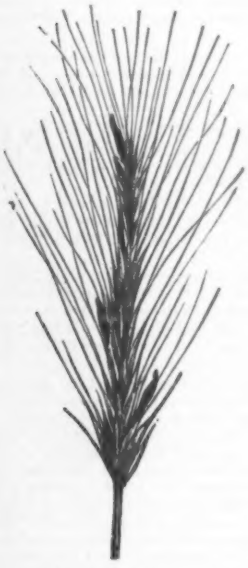


FIG. 1.

Barley grass, Hordeum murinum, Linn.

FIG. 2.

Timothy grass, Phleum pratense, Linn.

FIG. 3.

a. Ergot of wheat producing the small fungus, Claviceps purpurea, Tul. *b*. One of the heads magnified. *c*. Section through a head, to show the cavities containing the spores. (From Tulasne.)

FIG. 4.

Awnless darnel, Lolium arvense, With. L. temu lentum, L. var.

A grain of rye, covered with early, or sphacelia, state of ergot. Twice the natural size.

THE CATALPA.

THE great value of the catalpa tree is not appreciated by our farmers. Its cultivation should not be left to nurserymen, who grow it only to keep up their stock of trees intended exclusively for ornamental purposes. It is well enough, perhaps, to plant it along the edges of sidewalks in cities as a shade tree, though there are others which are more desirable. True, its blossoms are beautiful, and, during the period of its blooming, it is pleasant to look upon, and, when the flowers fall and cover the pavement, the effect of such a shower of beauty is recognized by every one who crushes the blossoms at every step as he passes beneath the tree. But this is an evanescent glory, though it makes one of the delights of springtime. The catalpa is lazy, and hangs back and dallies with the season. It is late in putting forth its broad leaves, and the first frost curls, shrivels, and blackens them. They soon fall to the ground, and leave the branches which bore them naked and forlorn.

But farmers being practical people, anxious to make money, and willing, as a rule, to do just that which will lead to such a result, do not care so much for the blossoms and the foliage of a forest tree, so that they realize profit from the wood it produces. To them the catalpa is invaluable. They ought to consider this fact with careful attention. The wood of this tree is practically indestructible, so far as wear and tear from exposure is concerned. It don't rot, whether in the ground or out of it. Once set as a fence post, it stands unaffected by the influences which cause all other posts, except cedar, to rot and fall. Fifty years may pass away and the catalpa post will still be fit for duty and hold its place firmly. When the young tree is only two years old and attains the size of a medium hop-pole, it can be cut for bean and hoop-poles, or for any other purpose for which a stake of that diameter is needed. A farmer in an adjacent county has catalpa bean poles which he has had in use for ten years, and they are as sound now as on the day on which they were first cut. So that in the infancy of the tree its usefulness begins and the young wood will continue to be serviceable for more than half a century afterward.

As to the propagation of the catalpa, that is easy. It has a peculiar talent for starting into life when the seed is placed in the ground. A small quantity of seed and very little labor would give to every farmer an acre of trees from which he could soon draw supplies for stakes, poles, and fence posts. It takes years of course to produce a tree that will be valuable for timber. But when the grove of catalpas is fairly set for timber purposes, it takes no labor to keep it

growing, and the land is increased in value year by year, from the very fact that it has one, two or ten acres devoted to the catalpa. And as the importance of the tree for timber comes to be appreciated, as it is sure to be, by just so much will the value of the land be enhanced. For culverts, bridges and all other exposed structures the time is coming when the catalpa will be eagerly sought for, because when once placed in position it can be relied upon to stay there unaffected by sunshine or moisture for fifty years at least, and it would not be extravagant to say a full century. At least such is the testimony of persons who have had opportunities of seeing it stand sound and firm during their life-time, and to have heard of its endurance from their fathers, who knew the identical log or post as sound and serviceable since their earliest boyhood.

The farmers' clubs all over the State should consider this question of growing the catalpa, as it is one of great practical utility and of absolute profit to landowners. Mr. E. E. Barney, of this city, has taken great pains to collect information concerning the growth of the catalpa. The results of his inquiries and the observation of those who can trace the history of certain catalpa posts and logs for a full century show clearly enough that its great value is established, though a general knowledge of that fact is not generally disseminated. It should be the special object of the farmers' clubs to open up the way for the cultivation of this valuable tree by discussing its qualities and considering the profit arising from such cultivation.—*Dayton Journal.*

BELGIAN OPINIONS ON ENGLISH SHORT-HORNS.

LAST year a party of Belgian landowners visited England for the purpose of studying the merits or defects of the short-horn breed of cattle. On their return home they published an account of their investigations, and we are indebted to the *Agricultural Gazette* for the following summary of their report:

The Provincial Council of East Flanders had decided in July last not to give any further encouragement to the introduction into that country of Durham bulls to cross with the native breed of cattle. In making this decision they had been influenced by a pamphlet published by the president of the agricultural committee of the province, in which it was stated that in England "the Durham race was only maintained by an abundant diet of oilcake and flour, of barley and oats; that the finest young cattle, male and female, of eighteen months to two years old, when placed in the richest pastures, still received their daily feed of corn; that the Durham race is considered as a machine for producing tallow and flesh, but has no aptitude for producing milk, cows of this breed unable to rear their calves being met with; indeed, that Durham beasts were but empty vessels, inflated beasts, laden with fat on the outside, but with beef very inferior in quality to that of our native breed of cattle."

A copy of this pamphlet being sent to Mr. H. M. Jenkins, the able secretary of the Royal Agricultural Society of England, and his opinion invited, he replied "that short-horns had never been more appreciated in England than at present; that although their special merit was early maturity, a short-horn beast being sold to the butcher at two years old, while a Dutch beast was not killed until four years old, the quality of beef of the short-horn was not surpassed by that of any other breed; that it was true the production of meat had been more studied than the production of milk, but that there were among short-horns some most excellent milking cows."

"Mr. Jenkins gave us," we continue our extract, "a pressing invitation to come to England with some of our friends. He traced out for us an excursion on the farms of some of the principal cattle breeders, and finished his letter by saying, 'When you have made the farming tour that I have arranged for you, you will be convinced that cows of this breed are in no way behind the best milking races of the Continent.'"

The journey was determined upon, and a dozen travelers—among whom were the President and Secretary of the Agricultural Society of East Flanders, MM. le Baron Favereau, Vice-President of the Eastern Agricultural Society; O. De Kerchove de Denterghem, President of Agricultural Section de Saffelaere, etc.—started upon what proved to them "the most interesting agricultural tour it is possible to imagine."

The first farm visited was Mr. Aylmer's, of West Durham, Norfolk. They walked over his pastures, remarking the vigorous growth resulting from top-dressings of nitrate of soda and superphosphate of lime, and inspecting his fine herd of 170 short-horn beasts, his flock of about 1,000 long-wooled Lincoln sheep, his 40 horses, and his pigs. The method of rearing and feeding Mr. Aylmer's short-horns, which are bred principally for beef purposes, is described. The horses are much admired. The precocity of the short-nosed pigs of the Prince Consort's breed astonished them. "We saw one less than 7 months old, a complete cushion of fat and flesh, in which one could scarcely discover the head or the legs." Several couples of pigs were purchased, surprise being expressed that this breed had not before been introduced into Belgium From West Durham they traveled to Leicester, and the following morning to the large dairy farms of Mr. W. T. Carrington, of Croxden Abbey, Staffs. They remark "that Mr. Carrington's special business being cheese-making, he seeks to have the best milking cows. These animals have a conformation quite different to those of Mr. Aylmer, in breeding which everything is sacrificed to the production of fat and flesh upon the shoulders, the back, and the haunches; here, on the contrary, the first consideration is the development of the milking qualifications, the lactiferous veins, the udder, and the escutcheon. To see these fine cows, one would take them for Dutch cows, if they had not a much wider development of the haunches, and if one did not always find them in a state of plumpness, which passes into complete fatness very soon after they have ceased to give milk."

They quote Mr. Carrington's opinion that the Durham breed of cattle is the best race of cattle for milking purposes when cultivated for that end, and describe some of the details of his management of dairy cattle. They remark that while in winter the milk is sent every night to London, to be sold there pure the following morning, in summer Mr. Carrington applies himself to the manufacture of fromage de Chester (many foreigners apply this term to all English cheese), so highly appreciated both in England and abroad. Having passed three hours on the farm, they inspected the dairy and cheese-room, being there not less interested than on the farm.

From Croxden Abbey they proceeded *via* Derby and Buxton to Manchester, "the scenery reminding them of Switzerland," and the busy aspect of Manchester, "the great industrial city of England, as animated as London," being remarked.

Lord Ellesmere's farms at Worsley were inspected the following day, where they found probably the largest and best stud of heavy horses and collection of pigs in England. In the absence of Lord Ellesmere, they were received by Captain Heaton, his lordship's well-known stock manager. They pronounced the pigs the finest and most perfect for the production of bacon they had ever seen, and gave orders to have several sent to Belgium for them. The horses were much admired, some of them being very fully described, and the prizes won by them noted. The parks and gardens were also visited and admired.

From Manchester they proceeded to Lancaster, and the next morning went to Holker to see the Duke of Devonshire's most valuable short-horn herd. The beauty of the route by rail by Arkholme, Carnforth, and Grange, with the sea on one side and the hills clothed with verdure on the other, is dwelt upon. Conveyed to Holker in the duke's carriages, they were received by his secretary in the absence of Mr. Drury, and proceeded to inspect the 300 head of short-horns, all of which they remark are of good pedigree and great value.

The duke, they add, "finds great satisfaction in occupying himself with everything relating to agricultural industry. During the whole period of his annual stay at Holker, there is not a day that he does not visit his farms and his gardens, at one time discoursing with a laborer, at another time with a farmer on his large domains, encouraging some, giving words of counsel to others, and finding for everyone a pleasant word.

"The greater number of laborers who are in the duke's service live in pretty cottages surrounded by gardens, kept in beautiful order. These great English noblemen ought to be taken as models by our rich proprietors on the Continent, who too often allow their laborers and farmers to live in miserable habitations.

"Everything denotes that in England agriculture is held in great honor. At the railway stations numbers of books are sold on agricultural subjects, one of which we bought, and intend to translate by and by."

After having passed in review the cattle at Holker, the production of milk from the best milking cows of which was said to be equal, if not superior, to that indicated by Mr. Carrington, the park, abounding with deer, was crossed, and the gardens and vineries were visited—the fine timber, the large bunches of grapes, and the splendid view of the sea from the terrace being specially admired. It now remained for them to visit the farm of Mr. T. C. Booth, the most celebrated breeder in England, which Mr. Jenkins had purposely reserved for the last visit.

"This farm, situated at Warlaby, in the midst of a fertile country, has an extent of more than 800 acres. Mr. T. C. Booth received us with the greatest cordiality. He presented to us his friend, Mr. Jacob Wilson, one of the directors of the English Agricultural Society, and his brother, another great breeder of cattle.

"Our interview with Messrs. Booth and their friend was the most interesting of our journey. Mr. Booth observed to us at first, as Mr. Aylmer's bailiff had also done, that there are two quite distinct varieties of short-horns, the one bred specially for the production of meat, the other more particularly for the production of milk. 'I occupy myself in producing both the one and the other,' added he. 'I will show you cows which give as much as 30 liters (6½ gals.) of milk during several months. It is, however, upon the formation of the most perfect meat-producing animals that my family have principally been occupied; and in my herd of horned stock, numbering more than 400 head, you will not find one in the two varieties which has not a pedigree which goes back at least 50 years.'"

They found collected in the meadows some very fine cows. Mr. Booth specially drew their attention to the five-year-old cow, Lady Fanny, as one of the best of his collection as a beef-producing animal, perfect in form, and worth in public sale from £2,000 to £3,000. He pointed out to them various marks of excellence in this and other cows, and also some special characteristics for which his herd is noted.

They remark upon "the great marks of constitution and vital force in Mr. Booth's cattle; their power of assimilating nourishment quickly and completely; their precocity, the heifers when placed with the bull at 14 months old being stronger and better developed than our heifers of three years old;" upon the increased development of those parts of the body where the best beef is found, and the diminution of bone and of the worthless parts of the animal.

"One of our party remarking that it had been pretended in Belgium that the meat of short-horns was not equal to that of other breeds, Mr. Booth replied that short horns had their detractors even in England, but that short-horns had been compared on many occasions with other races, but had never been judged inferior, either as to weight of inside fat or quality of beef; 'but you will have an opportunity of judging for yourselves,' said he, 'if you will accept the luncheon which presently I shall offer to you.'"

Mr. Booth then showed them one of his best milking cows, which gives after calving nearly 8 gallons of milk, and keeps up her extraordinary production sometimes for three months. This cow has a less taking appearance than the others, and her calves, though quite as well bred, are not as much sought after by purchasers. Mr. Booth pointed out to them in this cow the great distance from the eyes to the muzzle, which he considers a strong mark of a good milking cow.

The system of cattle management at Warlaby is described. Mr. Booth rears all his calves except defective animals, which are fattened and sold to the butcher. The bulls reared for stock purposes are kept in boxes until twelve or fourteen months old, when they are let out on hire yearly until they are too heavy or unprolific. There were 40 bulls belonging to Mr. Booth from twelve months to ten or twelve years old. The young bulls all had the mark of setons, which it is the custom to put in to prevent the black-quarter. Mr. Booth impressed upon his visitors the necessity of attention to pedigree in buying bulls to improve other stock, as it is only bulls of good pedigree which can be depended upon to transmit their qualities to their descendants.

After accepting freely of Mr. Booth's hospitality, and being thus convinced of the excellence of short-horn beef, they were each presented with a picture of that charming cow, Lady Fragrance, so well remembered by us as she stood in the "Royal" show-yard at Leicester, and bid farewell to their host, an excellent photograph of whom is placed at the beginning of this book.

"Thus terminated a journey with which we have all reason to be particularly satisfied."

A few general remarks and conclusions are added, which are of special interest:

"On all the farms we visited the culture is the most vigorous possible, rotation of cropping, green crop and white, is generally followed. The farm buildings are well constructed in an economical manner, and have a simplicity that we do not know here.

"The meadows in England are attended to in a particular manner, an abundant production of grass being one of the essential conditions of the prosperity of the farm. Superphosphate of lime and nitrate of soda are the principal aids to farm dung, and they produce an abundance of grass.

"The facts that we have related have an authentic character, which no one will, probably, venture to call in question.

"This journey enables us to make deliberately, and with confidence, the following assertions:

"1. That the short-horn race is composed of two varieties, quite distinct, and which must not be confounded—the one for the production of milk, the other for the production of meat.

"2. That in the one, as in the other variety, pure bred animals, both male and female, are in general superior to that of all other races.

"3. That they are very precocious, and qualified, though in different degrees, for fattening at every age, being remarkably adapted for this purpose.

"4. That the short-horn race, with a good pedigree, not otherwise, is a race essentially qualified to transmit its qualities to other races.

"5. Finally, that this race deserves to be bred with care, and actively propagated, not only for its own multiplication, but in order, by means of crossing, to improve those faculties which are not sufficiently developed in our own indigenous race."

BROOD MARES AND FOALS.

THE veterinary editor of the *North British Agriculturist*, in replying to a correspondent who had requested information on the management of brood mares and foals, says: "Horse breeders and farmers generally have a tolerably good idea as to the best management of their studs; but, like other erring mortals, do not always act up to their knowledge. Knowing what is right, they are prone, from want of thought and avoidance of trouble, to do what is wrong. To a few of the more common shortcomings in this department we endeavor briefly to advert. The mare far advanced in pregnancy sometimes continues tied up in her stall in a crowded stable, instead of enjoying the room, quiet, and comfort of a good box; and thus are increased the risks of accidents from other horses, and from getting cast in the stall, while the unwieldy mare, finding it difficult to lie down and get up in a narrow stall, is apt to stand persistently, to the detriment of her legs and her strength. Most mares during the last month of pregnancy are unfit for anything like work; but if not worked gently, they require regular exercise in a yard or paddock, or by being led about. The feeding is very important. It must not be too bulky to swell out the digestive organs, and thus diminish the amount of room needed by the foal; it must be sufficiently nutritive to sustain properly both mother and offspring; it must be rather laxative, so as to counteract the tendency to constipation, which is a serious matter when parturition arrives, and then is apt to cause straining and eversion of the uterus and other mischief. From causes not always explicable, the foal sometimes comes in a wrong position; the head is occasionally thrown backward, turned to the side, or down below the brim of the pelvis. Such misadventures are sometimes traceable to the mare having been knocked about, frightened, cast in her stall, or foaling having been brought on prematurely, and are more difficult to rectify in the mare than in the cow, for the mare strains violently, so that the requisite turning and proper placing of the foal for delivery is sometimes almost impossible, and, even with the administration of chloroform, the mare's life has often in such cases to be preserved at the sacrifice of the fœtus. As to the ailments from which your mares suffer after foaling, inflammation and internal hemorrhage, about which you inquire, are fortunately rare. Exhaustion, the result of a very hard parturition, or of previous overwork or insufficient feeding, is combated by digestible, easily assimilated food, and a pint of good ale repeated twice daily. A good many both of draught and lighter-bred foals are lost from their not taking to the teat. The mares are sometime troublesome or vicious, their udders are tender, their teats painful, and they strike out whenever the foal's nose touches the flank. A fidgety mare, and awkward or weakly foal, will often seriously try a man's patience for many hours until the foal is got to suck; and to save the foal it must be raised, and thus fed at least four times a day. Such help may continue to be requisite for a week; the mare's bag the meanwhile, if tender, must be rubbed with oil, and the teats damped with some mild astringent lotion. As to the examination of the milk, its physical and even its chemical characters do not always tell whether it will agree with the young foal, whose thriving will, however, soon indicate the condition of the milk. If faulty on one side, it will be so on the other. Foals sometimes scour, and die from the milk of mares in high condition, being too rich for the young animals, and in such cases it is wisdom for a week after parturition to withhold the corn or other such concentrated food, or greatly reduce its amount, and feed the mare mainly on mashes, hay, or grass. Occasionally the milk of bountiful mothers disagrees from its being secreted in larger amount than the young foal can take; it gets stale; and if the udder is not emptied several times a day, the foal scours. When the mother's milk disagrees, the first thing to be done is to change her food; if on dry fare, give her grass; if she has had mainly grass, give her dry food. A pint of barley supplied to the mare sometimes arrests scouring of the foal. If change of feeding, and removing night and morning any milk remaining in the udder, does not mend matters, and the foal does not thrive, or continues to purge, it must be tried with other food. Fresh cow's milk, diluted with about one-fourth part of water, and sweetened with an ounce of sugar to the quart, is a safe substitute for the mother's milk. Where the patient gets weak, a little wine and water, brandy and water, egg-flip or beef-tea is requisite. While the foal is thus nurtured artificially for a week or ten days, endeavor should be made to keep up the secretion of the mare's milk by milking her at least twice daily, or getting the bag emptied by another foal with which the milk may not disagree. The natural food, after an interval of ten days, may be found not to injure the foal, especially if return to it is made gradually."

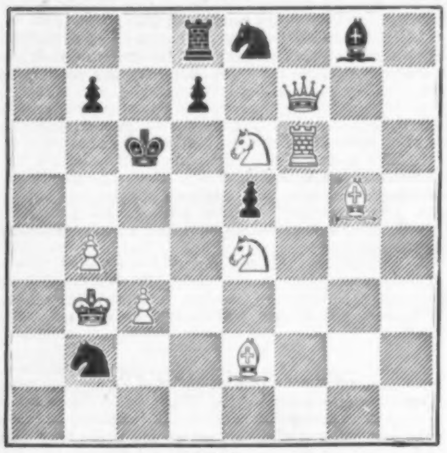
THE damage done to the mulberry trees by the last frost appears to be greater than was supposed in the first instance. In France the foliage is more backward than the worms, and in some cases of premature development it has been necessary to throw away the latter in consequence of a want of food supply; but it is only during the last week that the great majority of French cultivators have begun to hatch. In Spain the worms are progressing favorably, and the news from Italy is not adverse.

Scientific American Chess Record.

[All contributions intended for this department may be addressed to Samuel Loyd, Elizabeth, N. J.]

Problem No. 86. By Miss M. Rudge.

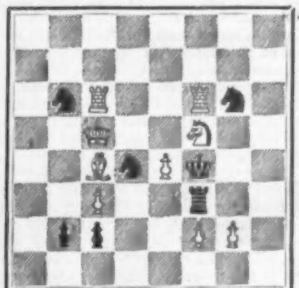
Black.



White.

White to play and mate in four moves.

MISS M. RUDGE, OF LEOMINSTER, ENGLAND.



White to play and mate in 3 moves.
Association Letter Tourney.

Having introduced the American "Chess Queen" to our readers, we feel in honor bound to also present the likeness of Miss Rudge, whose recent achievements in winning a series of matches from Mr. Thorald, as well as the third prize in the Grantham Chess Tournament, and the second prize in the British Counties Chess Association of 1874, have gained for her the reputation of being the strongest lady chess player in England, and we have seen it suggested in several of our exchanges that a trial of skill should be arranged between our fair representatives. This might readily be done, as both Miss Rudge and Mrs. Gilberg are equally famous as correspondence players.

Miss Rudge comes of a chess-playing family, but wields the scepter, we are informed, over parents and sisters. Aside from being a skillful player, she has also essayed the higher branch of composition, and we have seen several of her problems which were remarkably clever. We regret, however, that we can recall but one of them, and cannot therefore give a selection that would do greater justice to the talents of the fair artist. We select a game contested with Mr. F. C. Collins, the well-known English problemist.

GIUOCO PIANO.

	Miss M. Rudge.		Mr. F. C. Collins.
	WHITE.		BLACK.
1.	P to K 4	1.	P to K 4
2.	K Kt to B 3	2.	Q Kt to B 3
3.	B to Q B 4	3.	B to Q B 4
4.	P to Q B 3	4.	Kt to K B 3
5.	P to Q 4	5.	P x P
6.	P to K 5	6.	P to Q 4
7.	B to Q Kt 5	7.	K Kt to K 5
8.	B x Kt ch	8.	P x B (a)
9.	Kt x P	9.	Castles.
10.	Castles.	10.	B to Q 2
11.	B to K 3	11.	Q to K 2
12.	P to K B 4	12.	P to K B 3
13.	P x P	13.	K R x P
14.	Q to K B 3	14.	Q R to K B sq (b)
15.	Kt to Q 2	15.	Kt x Kt (c)
16.	B x Kt	16.	B to K B 4
17.	Q R to K sq	17.	B to K 5
18.	Q to K 2	18.	Q to Q 2
19.	B to K 3	19.	B to Q Kt 3
20.	Q to Q 2	20.	P to B 4 (d)
21.	Kt to K B 3	21.	B x Kt
22.	R x B	22.	Q to Q 3
23.	B to B 2	23.	R x P
24.	R x R	24.	Q x R
25.	Q x P ch	25.	Q to K B 2
26.	R to Q sq	26.	P to Q B 5
27.	Q x Q ch	27.	R x Q
28.	B x B	28.	B P x B
29.	R to Q 8 ch	29.	R to B sq
30.	R x R ch	30.	K x R
31.	K to B 2	31.	K to K 2
32.	K to K 3	32.	K to Q 3
33.	K to Q 4	33.	P to Q Kt 4
34.	P to Q R 4	34.	P to Q R 3
35.	P to K Kt 3	35.	P to K R 4
36.	P to K R 4	36.	K to B 3

And the game was given up as drawn.

(a) So far all is "book."

(b) R to K sq looks stronger, threatening to win a pawn at least.

(c) Why not R take P?

(d) R to Kt 3 seems more attacking.

CHESS ON THE STAGE.

In Supplement No. 121 we gave a short account of living chessmen. We recollect the following further particulars in that curious London journal, *Notes and Queries:*

Some fifteen or sixteen years since, on the opening of the Lowther Rooms, in King William street, Strand, since the temporary chapel of the Oratorians, and still more recently occupied as Mr. Woodin's Polygraphic Hall, there was a large chessboard laid on the floor, and men and women, dressed as pawns and pieces, were in attendance for the use of those who might choose to play at what was termed "living chess." The manner was as follows: The players were mounted in two boxes, something like pulpits, and directed the living chessmen to move, or take an opponent, which was always conducted by an encounter of weapons, and the defeated person driven off the board. The charge was five shillings each player per game, and the public were admitted at one shilling each as spectators.

This account may be relied on, as the writer, being a lover of the game, once ventured to play a game with the "living chess;" but he found that, however novel the affair was, though it might do for once, yet the battling of the men and their not being specimens of "still life" was very perplexing to the player, and from the fidgeting of the individual chessmen he was in momentary expectation of seeing some of his pawns or pieces take huff and walk off the board without leave. The speculation was not a successful one, as few good players adopted a second edition of the game; so it remained open but two or three months, and the kings, queens, bishops, knights, rooks, and pawns doffed their costume and sought employment in some other sphere where they were more at liberty to follow their own inclination than at "living chess."

Several attempts to again introduce chess upon the stage in Paris and elsewhere have met with the same want of success, although performances of this kind have been of frequent occurrence. Don John of Austria, a certain Duke of Weimar, and many others are known to have played with living chessmen upon large checkered boards made for the purpose. At a fete given in Hanover by the Minister of Foreign Affairs, the festivities began with a procession of living chessmen consisting of kings, queens, knights, and other pieces gorgeously attired. After this display the walking pieces took up their proper positions on a gigantic chessboard, where, under the direction of two magicians in costume, they played a game which excited great interest, and afforded much entertainment to the fortunate spectators.

MISS M. RUDGE, OF LEOMINSTER, ENGLAND.

In the early part of the seventeenth century chess made its appearance upon the stage. Thomas Middleton wrote a comedy styled "A Game of Chess," which was acted at the Globe Theater (Shakespeare's play-house) nine times in succession. The prologue reads thus:

"What of the game, called chess play, can be made
To make a stage play, shall this day be played.
First you shall see the men in order set,
States and their pawns, when both the sides are met.
The houses well distinguished: in the game
Some men entrapt, and taken to their shame,
Rewarded by their play: and in the close
You shall see checkmate given to virtue's foes.
But the fairest jewel that our hopes can deck
Is so to play our game t' avoid your checke."

It abounds in such stage directions as "enter White Bishop," "enter White Queen's Pawn, with a booke in her hand," and so on. We remember one place where the Black Knight's Pawn displays his contrition for some evil deed, by saying:

"The sting of conscience
Afflicts me so for that inhumane violence
On the White Bishop's Pawn, it takes away
My joy, my rest."

In another part of the comedy the Black Knight assaults the White Queen's Pawn in the following bloodthirsty manner:

"Make thy selfe ready for perdition,
There's no remove in all the game to 'scape it;
This Pawn, or this, the Bishop or myselfe
Will take thee in the end, play how you can."

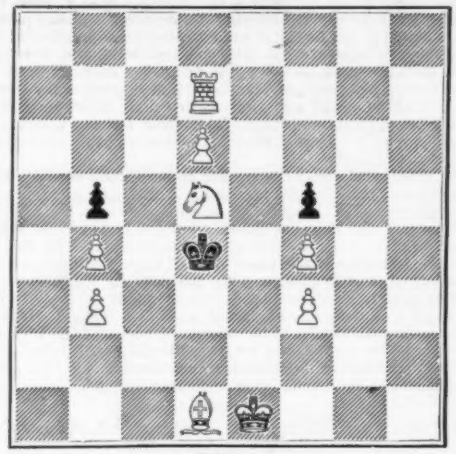
It seems to have been a sort of bitter religious satire, which, being offensive to the partisans of the Catholic Church, James I. suppressed it, and the unlucky author was committed to prison, where he remained until the following whimsical petition to the chess loving monarch procured his release:

"A harmless game, coin'd only for delight,
Was played 'twixt the black house and the white.
The white house won, yet still the black does brag
They have the power to put me in the bag.
Use but your royal hand 'twill set me free,
'Tis but removing of a man—that's me."

Problem No. 87. By W. A. Shinkman

First Prize in Brownson's Tourney No. Four.

Black.



White.

White to play and mate in four moves.

SOLUTIONS TO PROBLEMS.

No. 80.—By J. Dobrusky.

WHITE.	BLACK.
1. Q to R 8	1. Kt x Q
2. B to R 8	2. Any move
3. Mates.	
	1. B x Q
2. R x P ch	2. K x B
3. Kt to Kt 6 mate.	
	1. K x R
2. B to Kt sq ch	2. K x B
3. Q to R sq mate.	

No. 81.—By Rudolph Wilmers.

WHITE.	BLACK.
1. Q to R 2	1. P x R
2. Kt to K 7	2. R x P
3. Q to K 2 ch	3. K moves
4. Kt to Kt 6	4. Moves
5. Q mates.	

Letter "I."—By J. B. Munoz.

WHITE.	BLACK.
1. K to B 3	1. Any move
2. B to K 4 mate.	

Enigma No. 47.—By J. A. Graves.

WHITE.	BLACK.
1. Q to Q R 4	1. Any move
2. Mates accordingly.	

DUBUQUE TOURNEYS NOS. 4 AND 5.

In concluding the record of these interesting and agreeable tournaments of Prof. Brownson, we must again remark that the conditions as well as data of the tournaments are not clearly stated in the Tournament Book, and we can only surmise that the tournaments were inaugurated in the spring of 1871. In Tournament No. Four, the first prize was awarded to a most clever composition by W. A. Shinkman, to which we call the especial attention of our solvers.

The second and third prizes were awarded to two of our old friends, and the fourth to Rev. L. W. Mudge, as given in Supplement No. 105.

Enigma No. 54.—By C. H. Gilberg. Second Prize.

White.—K on Q B sq, R Q B 5, Bs K R 2 and Q sq, Kts Q Kt 4 and Q 7, Ps Q R 3 and Q 3.

Black.—K Q 5, R K R 3, Bs Q Kt 2 and K B 3, Ps Q R 2, Q Kt 4, K 6, K B 6 and 7, and K Kt 2.

White to play and mate in three moves.

Enigma No. 55.—By G. E. Carpenter. Third Prize.

White.—K on Q R 4, Q Q 2, B Q R 3, Kts K Kt 2 and K R 7, Ps Q Kt 2, K B 4 and K R 3.

Black.—K K B 6, Q K Kt sq, R K R sq, B K Kt 8, Kt Q Kt sq, Ps Q Kt 5 and 6, Q B 7, Q 4 and 6, K 6 and K B 4.

White mates in seventeen moves.

Tourney No. Four seems to have been based upon two absurd stipulations of "white to play so as to allow black to mate," and "white to retract his last move and mate," which ideas were first suggested in a burlesque sketch contributed by us to the *Chess Monthly* twenty years ago.

Both the first prizes were awarded to Shinkman, the second prizes to Shinkman and T. M. Brown, but the positions are not worth preserving.